

Price Distortions in the Combinatorial Clock Auction – a Bidder Perspective

Richard Marsden, NERA Senior Vice President

Soren Sorensen, NERA Associate Director

April 2015

1. Introduction

Proponents of the Combinatorial Clock Auction (CCA) often argue that the format has two key advantages over the Simultaneous Multiple Round Auction (SMRA): (i) the CCA eliminates aggregation risk by allowing for package bids, and (ii) the CCA facilitates efficient outcomes through incentives for straightforward value based bidding.¹ While the first argument is irrefutable, the second argument is often questioned by practitioners, and recently by the academic literature on auctions as well.²

In this paper, we address the question of whether the CCA provides incentives for straightforward bidding in the context of spectrum auctions. The paper builds on the authors' practical experience with designing spectrum auctions and advising bidders participating in them, spanning more than a decade. Notably, at NERA Economic Consulting, the authors have advised mobile operators on bid strategy in CCAs in countries around the world, including Canada (2014 & 2015), Slovenia (2014), Slovakia (2013), Australia (2013), UK (2013), Denmark (2012), Ireland (2012) and Switzerland (2012). In addition, Richard Marsden, in his

¹ For example, in the abstract of his paper on the CCA, Cramton (2012) says that “the pricing rule and information policy are carefully tailored to mitigate gaming behavior”. Similarly, the Irish regulator ComReg (2012, p. 70) states that their consultancy firm DotEcon notes, “...the second price rule is utilized to disincentivise gaming behavior and encourage straightforward bidding”. And Ofcom (2015, A8.122) states that “[t]he fundamental rationale for the CCA as an auction format is that it provides incentives for straightforward bidding by bidders.”

² See Maarten Janssen (2015), “Price Distortions in Combinatorial Clock Auctions, a Theoretical Perspective”.

previous role at DotEcon, was a lead member of the team that designed and implemented CCAs in the UK (2005-10), Denmark (2010) and the Netherlands (2010).

Evidence from recent CCAs suggests that bidders often do not bid straightforwardly in practice, and there are a number of possible explanations for this. In Section 2, we provide a list of reasons why bidders may not follow the advice of straightforward bidding. The list includes complexity, the impact of the core pricing principle, budget constraints, preference for good relative outcomes and strategic investment incentives. Each of these factors provides a rationale for deviating from straight forward bidding under certain circumstances.

In Section 3, we explore the extent to which prices in recent spectrum auction have been affected by these factors. In our experience, incentives to deviate from straight forward bidding are usually very specific to local circumstances and may vary greatly from bidder to bidder. We use three case studies, focusing on the Irish 4G Auction (2012), the UK 4G Auction (2013), and the Austrian 4G Auction (2013), to illustrate this point.³ We pick these three auctions because they are particularly relevant to UK regulator Ofcom's consultation on annual licence fees (ALFs) for 900 MHz and 1800 MHz. For all three auctions, Ofcom has argued that there is no strong evidence to suggest that absolute relative prices were significantly affected by strategic bidding.⁴ We strongly disagree with this conclusion, although the extent to which prices were likely distorted varies greatly for each auction.

Section 4 summarises our conclusions.

³ In the Irish and UK auctions, we advised Telefonica Group companies. We were not involved in the Austrian auction.

⁴ Ireland: Annual licence fees for 900 MHz and 1800 MHz spectrum: further consultation (August 2014 Consultation), at §3.51; Austria: 2014 Consultation, at §A8.50, and February 2015 Consultation, at §3.54.A; UK 4G: Annual licence fees for 900 MHz and 1800 MHz spectrum: Provisional decision and further consultation (February 2015 Consultation), at §2.142.

2. Reasons for deviating from straight forward bidding in a CCA

Straight forward bidding in a CCA describes a strategy where a bidder: (a) bids each clock round for the package with the highest surplus (intrinsic value of package less clock price of package); and (b) submits bids at full valuations for all desired packages in the supplementary round.⁵ In a number of CCAs, regulators have gone so far as to advise bidders to consider this strategy, de facto arguing that it is a (weakly) dominant strategy and provides bidders with a simple way to overcome complexity of the CCA.⁶

The theoretical basis for such advice is the close similarity between the winner and price determination mechanisms in the CCA and the VCG mechanism (or Vickrey auction), which has the property that in simple cases bidders can do no better than submitting bids that correspond to their intrinsic valuations. However, the CCA differs from the Vickrey auction in a number of important aspects. First, some multi-band CCAs can have billions of potential bid options (packages), which pose a complexity problem for a bidder who is intending to follow straight forward bidding. Second, the pricing rule in a CCA is a modified Vickrey pricing rule, which does not have the property that bidders can do no better than better than submitting bids that correspond to their intrinsic valuations. For these reasons alone, straightforward bidding can be dismissed outright as a dominant strategy in a CCA. Moreover, as we will show below, it is often not even a good strategy if bidders care about relative outcomes or have budget constraints.

When advising bidders on how to approach bidding in a CCA, we typically start by introducing straightforward bidding as a default strategy for all bidders. As with any spectrum auction, the challenge is then to identify circumstances that may lead bidders to deviate from

⁵ Note that straight forward bidding during clock rounds enables a bidder to bid full valuations in the supplementary round.

⁶ For example, ComReg states that “...using a CCA makes a ‘strategic demand reduction’ strategy redundant and that ComReg’s auction format proposal encourages straightforward bidding”. See Paragraph 3.48 of Response to Consultation on the draft Information Memorandum, ComReg 12/50, 25 May 2012.

straightforward bidding. Table 2.1 below lists five reasons why bidders may deviate; in each case, we characterise them with respect to how they might affect prices relative to the market level (up, down or ambiguous) and how big an impact they may have on prices (large, small or ambiguous). This assessment is based on our practical experience with advising bidders in CCAs.

Table 2.1: Overview of reasons for deviating from straight forward bidding

#	Reason for Deviation	Effect on price level	Importance in practice
1	Complexity	Down	Usually Small
2	Pricing rule	Ambiguous	Small
3	Budget constraints	Ambiguous	Large
4	Relative outcome	Up	Large
5	Strategic investment	Up	Ambiguous

We deliberately exclude strategic demand reduction from this list. Although there are a number of examples of multi-band CCAs where bidders could, in theory have benefited from tacit agreement to reduce demand, our experience is that the auction format is highly effective in deterring such behaviour. We return to this point in our discussion of price driving activity associated with securing good relative outcomes below.

In the following sections, we discuss how bidders in practice respond to each of these five reasons for deviating from straight forward bidding.

2.1. Complexity

Multi-band CCAs with many lots are complex. There may be billions of bid options (packages) that each bidder could bid on. This is a challenge from a valuation perspective and also for the auctioneer in terms of the speed of processing the winner and price determination algorithms. As a result, the number of bids each bidder can submit in the supplementary round is often limited to say 5,000 bids or less.

In many auctions this is not a problem. As an example, no bidder in the UK 4G auction (2013) could bid on more than 3,000 packages owing to spectrum caps and competition constraints, which implied that bid options were not artificially limited in the supplementary round. On the other hand, for CCAs with regional lots, such as Australia (2013) and Canada (2014, 2015), the limitation of bid options implies that bidders may in fact not be able to bid straightforwardly. Bidders have to select packages strategically, and the packages that are not bid on will effectively have a zero bid, which differs from actual valuations.

In theory, the possibility that bidders fail to bid on some packages means that price levels may be depressed. If bids are missing, prices can only decrease (or stay unchanged), but never increase. However, in practice, our experience is that the limitation of bid options is typically a minor issue. The fact that the supplementary round happens after the clock phase means that bidders always have some ability to narrow their attention to a smaller set of packages which are relevant either as potential winning bids or as price setting bids. Other potential bids that will clearly have no impact on outcome can be discarded. A well prepared bidder is typically able to identify the supplementary bids that matter, especially as Auctioneers typically give bidders two or more days to prepare these bids, provided aggregate demand data is available.

Summary: Complexity in terms of the number of bid options may lead bidders to deviate from straightforward bidding. In practice, this is usually of low importance as bidders can identify the bids that really matter for determining allocation and pricing.

2.2. Modified Vickrey pricing rule

The pricing rule used in all CCAs to date is a modified Vickrey pricing rule⁷, which is based on the principle of ‘happy winners, happy losers’, i.e. the so-called core pricing principle. Under

⁷ Examples where a pure Vickrey pricing rule was used are assignment rounds in the Swedish 1800MHz auction (2011) and the New Zealand 700MHz spectrum (2013).

this principle, prices have the property that no bidder (or group of bidders) has offered to pay more than the prices paid by any winner (or group of winners).

The following simple example illustrates how bidders may gain from deviating from straightforward bidding under such a pricing rule. Suppose there are two lots available in the auction and there are three bidders; each bidder has a valuation for winning two lots, but only two of the bidders have a valuation for winning one lot, as outlined in Table 2.2 below.

Table 2.2: Example of valuations

	Valuation for 1 Lot	Valuation for 2 Lots
Bidder A	100	150
Bidder B	100	150
Bidder C	-	150

First, suppose all bidders bid their value. In the winning allocation, bidders A and B both receive one lot each. This allocation generates a value of 200, while any alternative allocation (when taking out either or both of the winning bidders) has a value of 150. In this example, the Vickrey price for both winning bidders is 50, but they jointly have to pay 150 to make bidder C a happy loser, hence a ‘core adjustment’ of 25 is added to the Vickrey price for each winning bidder.⁸

Table 2.3 provides a summary of the winning allocation, prices and surplus for all bidders, when they all bid straightforwardly.

⁸ Here we assume the core adjustment is calculated by minimising the sum of squared differences between Vickrey prices and base prices, i.e. so-called Vickrey nearest core prices.

Table 2.3: All bidders bid straight forward

	Winning Package	Vickrey Price	Core Adjustment	Core Price	Surplus
Bidder A	1 lot	50	25	75	25
Bidder B	1 lot	50	25	75	25
Bidder C	-	-	-	-	0
Total	2 lots	100	50	150	50

Essentially, the opportunity cost imposed by bidder C is shared between the winning bidders, A and B. Our continued example below shows how the ability to shift the shared surplus from one bidder to another creates an incentive to deviate from straightforward bidding.

Suppose bidder A inflates his bid for 2 lots from 150 to 160, i.e. a deviation from straightforward bidding. The winning allocation is unchanged, but the Vickrey price for bidder B is now 60, while it remains at 50 for bidder A. As a result, the two winning bidders only have to share an additional opportunity cost of 40, imposed by the losing bidder C. As this is shared equally, bidder B enjoys a reduced payment and higher surplus as a result of its strategic bidding behaviour, as illustrated in Table 2.4. Of course, Bidder A has similar incentives.

Table 2.4: Bidder A inflates bid for 2 lots

	Winning Package	Vickrey Price	Core Adjustment	Core Price	Surplus
Bidder A	1 lot	50	20	70	30
Bidder B	1 lot	60	20	80	20
Bidder C	-	-	-	-	0
Total	2 lots	110	40	150	50

The effect on the overall price level is ambiguous. In this particular example, the auction revenue is unchanged as the winning allocation does not change, and the winning bidders

jointly pay the same amount. Price levels will only be affected when bidders ‘get it wrong’ and the attempt to shift pricing onto rival bidders fails (e.g. bidder A inflates his bid so much that he actually wins both lots). It should also be noted that shifting pricing onto rival bidders does not necessarily require inflation of bids. In the example above, bidder A would have created the same effect if he had decreased his bid for 1 lot to 90. The key is that bidder A inflates the difference between his bids for 1 and 2 lots, such that bidder B faces a larger opportunity cost.

It is widely recognised that the pricing rule in CCAs creates an incentive to deviate from straightforward bidding.⁹ However, in practice, we have only come across this issue as a relevant factor in bid determination in the context of combinatorial sealed bids with simple lot structures. With multi-band auctions, our experience is that there are too many package options for each bidder to predict reliably how its bids may affect price outcomes where core adjustments are involved. Moreover, in large auctions, such considerations are typically second order compared to issues such as budget constraints and relative outcomes, which we turn to next.

Summary: The pricing rule in CCAs provides an incentive to deviate from straightforward bidding under some conditions. In practice, unless the lot structure is very simple, it is typically too difficult for bidders to identify opportunities for such behaviour. The effect on price levels is ambiguous.

2.3. Budget constraints

In high-value spectrum auctions, bidders often face hard budget constraints, with the implication that they may be unable to express their true value differences between alternative packages; hence straightforward bidding for all target packages may be impossible. This is

⁹ See e.g. Goeree J.K., and Y. Lien (2012). On the impossibility of core-selecting auctions, Theoretical Economics (forthcoming).

often a key issue for smaller bidders, but in large multi-band auctions it may even affect large well-financed bidders.

To illustrate the point, consider a simple example where Bidder A is competing against Bidder B in a one band CCA for two lots. Suppose his valuation is 100 for 1 lot and 150 for 2 lots, and the bidder has a budget constraint of 125. By implication, the bidder enters the process knowing that he will not be able to express his full value for the larger package, so strictly straightforward bidding is not an option for this bidder.

In general, this bidder has two different strategy options (as well as many variations within these two extremes):

- **Delta preserving strategy:** Bidder A could reduce the overall level of bids and preserve the delta between bids: Bid 125 for 2 lots and bid 75 for 1 lot. This strategy carries the risk of winning 0 lots where he could have won 1 lot. However, if Bidder A does win 1 lot, it does assure that Bidder B pays Bidder A's full opportunity cost.
- **Delta reducing strategy:** Bidder A could cap his bids at the budget level, thereby reducing the delta between bids for some packages: Bid 100 for 1 lot and bid 125 for 2 lots. This strategy maximizes the likelihood of winning 1 lot, but may mean foregoing a winnable 2nd lot and/or having Bidder B secure the same spectrum at a much lower price.

This dilemma is most acute in the context of a sealed bid combinatorial auction. To an extent, the CCA can help ease the budget constraint dilemma for the bidder, owing to price discovery in the clock rounds. In our simple example, the bidder could adopt a straightforward bidding strategy for 2 lots up to a price of 50, then drop back to 1 lot and bid on this package up to its valuation of 100. Suppose the clock rounds end at a price of 74 per lot. At this price, Bidder A will be facing one of two possible situations:

- First, in case there were no unsold lots (which by implication must mean that Bidder B dropped demand from two lots to one lot), Bidder A has a so-called knockout bid for 1 lot

at a price of 75.¹⁰ If he submits a bid of 75 for 1 lot, he is guaranteed to win at least this lot at a price that does not exceed 75. In this case, the bidder can also express an incremental value of 50 for a second lot, i.e. he would bid 125 for 2 lots, which is just within his budget limit. In this case, Bidder B will pay Bidder A's full opportunity cost for 1 lot (of course, if the closing clock price had been higher, this would not have been possible).

- Second, in case there is one unsold lot at the end of the clock rounds (which by implication must mean that Bidder B dropped demand from two lots to zero), the bidder faces a knockout bid of 149 for 1 lot (by adding the value of the unsold lot). Such a knockout bid exceeds the bidder's budget constraint. In this case, the bidder has little but to submit a bid of 100 for 1 lot, so as to maximize his chances of getting at least 1 lot, and a bid of 125 for 2 lots. In this case, if Bidder B does bid for and win 1 lot, it will only pay 25, much less than Bidder A's true valuation differential.

The budget constraint issue is generic to second price auctions where bidders typically pay less than their winning bid.¹¹ In our simple example, Bidder A can reliably predict it will not win 2 lots, so at least the clock rounds provide guidance on how best to deviate from straightforward bidding, i.e. focus on a delta reducing strategy. However, with a more complex lot structure, especially one with multiple bands and substitutable lots across bands, bidders may not face such a clear choice. In our work for bidders on European multi-band auctions, we have often identified situations where a budget-constrained bidder faces non-obvious choice between the delta reducing and delta maximising strategy.

¹⁰ A knockout bid is a bid in the supplementary round that guarantees a bidder wins his final clock round package. In some cases a good rule of thumb for a knockout bid is to simply add to your final round bid the value of unsold lots at final round clock prices plus £1 to avoid tie-breaks. However, the validity of this rule of thumb depends on the details of activity rules etc. In the context of the Irish CCA (2012), ComReg provided an exact formula for the knockout bid, see Annex 9 of "Multi-band Spectrum Release, Information Memorandum", ComReg 12/50, 12 May 2012.

¹¹ See e.g. Ausubel, Lawrence M. and Paul Milgrom (2006) "The Lovely But Lonely Vickrey Auction," in Peter Cramton, Yoav Shoham, and Richard Steinberg, eds., *Combinatorial Auctions*, MIT Press.

The dilemma is particularly acute if a bidder ends the clock rounds on a large target package but cannot afford the knock out bid to guarantee that package. In this case, it faces a choice between bidding as high as possible for that package and not making any back-up bids for smaller packages, or submitting back-up bids that may out-compete its preferred package. The best course of action is non obvious, as it depends on competitor bids. In either case, it involves deviation from straightforward bidding

One way that bidders can attempt to ease uncertainty is by tracking activity of rival bidders during the clock rounds, so as to predict their supplementary bid round constraints. Taking into account spectrum caps and activity rules, it may be possible to identify a lower knock-out bid level than simply adding the value of unsold lots, which may be help to avoid reaching a budget limit. However, this is not straightforward, as Auctioneers typically only provide aggregate demand data, meaning bidders have to guesstimate based on the predictable demand of rival bidders.

As bidders with budget constraints typically underbid for larger packages, it may be expected that this issue will normally be associated with lower overall prices. This is because budget constrained bidders may express an artificially low delta for large packages that set the opportunity cost for rival bidders.

However, if bidders anticipate that their rivals have budget constraints, this may also create incentives for overbidding. Consider our simple example above. Suppose Bidder B correctly predicts that it has similar values to Bidder A but has no budget constraint. If it bids straightforwardly, both bidders will win 1 lot at a price of 50. However, if it overbids for 2 lots, then drops to zero at say a price of 60 per lot, it will force Bidder B to confront its budget constraints. Bidder A will bid its maximum 100 for one lot and 125 for 2 lots, so Bidder B will only pay 25 to win 1 lot, a gain of 25. Depending on the supplementary bids made by Bidder A, it could force Bidder A to pay anything up to 95 without risk of winning. Therefore, in this

case it is possible that prices could even rise in the presence of budget constraints if they incentivize strategic overbidding.

In practice, we have observed behaviour of this type in a number of multi-band CCAs. As the knockout bid for a final round package in many cases is roughly equal to the final round bid for that package plus the value of unsold lots, the required knockout bids may be inflated by rival bidders when they close the clock rounds by reducing demand to an extent that creates unsold lots. The presence of spectrum caps or set asides (see for example the Irish and UK case studies below) may even make this a risk-free strategy.

As the presence of unsold lots at the end of clock rounds is often a cause of great uncertainty, this may be exploited in the presence of budget constrained bidders.

Summary: Budget constraints are important in practice and imply that bidders do not always have the option of straightforward bidding. The response varies and is often tailored to the specific circumstances. The effect on price levels is ambiguous.

2.4. Preference for good relative outcomes

Relative outcomes matter in spectrum auctions. An obvious way to evaluate the success of a bidder's strategy after the auction is to compare the prices that different firms have paid for similar spectrum. A bid strategy is often considered to be unsuccessful if another bidder paid a substantially lower per MHz price for similar spectrum. Good relative outcomes may be particularly important for bidders acquiring less spectrum than others in an auction, as such bidders must rationalise to shareholders why they won less.

In a large multi-band spectrum, the amounts spent may also be sufficiently large as to impact on their ability to spend after the auction on marketing and network upgrades. Bidders that spend more in large auctions may find that it is harder to gain budget from shareholders for other activities or that it is more expensive for them to secure external finance for future

investments. In certain circumstances, increasing the price rivals pay for spectrum in an auction may effectively may delay or otherwise obstruct investments of competitors in increasing the quality of their networks. This may give the bidder who gets a good relative outcome a competitive advantage in the market after the auction vis-à-vis its rivals.

As bidders set each other's prices in a CCA, it is common for bidders to identify opportunities for deviations from straightforward bidding that can increase rival's costs without affecting the bidder's own price. Typically these involve substantial overbidding on lots where rivals have predictable demand. Bidders can and do act on these opportunities. In the academic literature, this has been described as "spite" bidding, but we dislike the term because it implies that such behaviour is purely offensive.

In practice, our experience is that bidders often engage in price setting behaviour for two defensive reasons:

1. If they don't engage in such tactics, they fear that others will and they will pay much more for similar spectrum. In this context, the example of Sunrise which paid more for a strictly smaller package of spectrum than Swisscom in the Swiss 4G auction is often held up as an example of an outcome that no one wants to replicate
2. By over-bidding, it may be possible to exert price and budget pressure on a rival that would otherwise not exist, thereby increasing the chance that surrender other target lots. This may be particularly relevant in a multi-band auction, when bidders are bidding on large packages of lots that are both substitutes and complements.

A simple example of a 900MHz band with 7 lots, which is loosely based on a real situation from a European multi-band auction, illustrates the point. Suppose there are three bidders and a spectrum cap of three lots per bidder. Bidder A is a strong incumbent which predictably will demand 3 lots and has valuations and budget that cannot be beaten. Bidder B is a smaller incumbent with a legacy 900 MHz network; it has a substantial value on 3 lots and a minimum

demand of 2 lots. Bidder C is the smallest incumbent and its legacy network is less dependent on 900 MHz; it has a substantial value for 2 lots and a minimum demand of 1 lot. Suppose that in all case, the value of incremental lots is strictly descending and, for simplicity, that the reserve price is zero.

If the bidders bid straightforwardly, the clock rounds will end in one of two ways:

- Bidder C reduces demand to 1 lot. The other two bidders each win 3 lots and pay an identical price, based on the opportunity cost of bidder C not winning a 2nd lot. Effectively the two larger bidders are paying opportunity cost for 1 lot while winning 3 lots.
- Bidder B reduces demand to 2 lots. In this case, Bidder A wins 3 lots and Bidders B and C each win 2 lots. Observe that Bidder C did not drop demand, so it imposes no opportunity cost on its rivals. As a result, Bidder B takes two lots at zero price. However, Bidder C has to pay the opportunity cost of denying one lot to Bidder B. Meanwhile, Bidder A pays the same price as Bidder C, even though it wins one more lot.

Neither outcome is very attractive for our smallest bidder, Bidder C. In the second case, it faces paying a substantially higher price per MHz than its two stronger rivals. Is there anything it can do to avoid this? Yes, it could start the auction by bidding on 3 lots and keep bidding on 3 lots until either (a) bidder B drops to 2 lots, thereby accommodating his demand for 2 lots; or (b) he becomes worried about the risk of winning 3 lots, in which case he drops to zero lots, knowing he can pick up 1 lot in the supplementary round owing to the spectrum cap. This is obviously a much better strategy than straightforward bidding. In case (a), he pays the same price for 2 lots as in the straightforward case, but he can impose the same cost on Bidder B, so he does not look like he overpaid. In case (b), he only wins 1 lot, but imposes a much higher prices on his rivals. Moreover, by imposing greater price pressure on Bidder B through the clock rounds, he increases the likelihood that Bidder B drops demand without any impact on his own price.

This simple example illustrates that the key to securing a good relative outcome in a CCA is exploiting the predictability of demand for rival bidders. Without such predictability, a bidder who is bidding above valuation is exposed to the risk of winning lots at prices it does not want to pay. For this reason, this kind of over-bidding is most often observed in legacy bands, such as 900MHz, where some bidders have predictable irreducible demand levels owing to need to provide service continuity to their legacy GSM and 3G customer bases. In the context of a multi-band auction, this has the potential to lead to gross asymmetries in relative prices during the clock rounds, as bidders deliberately drive up prices in some legacy bands where rivals have predictable demand, while bidding more straightforwardly in other bands.

The general importance of good relative outcomes is of course independent of the auction format that is used. However, owing to the pricing rule, this motive can lead to very different behaviour in a CCA as compared to, say, an SMRA. Specifically, identical situations can lead to incentives for overbidding in a CCA and underbidding in an SMRA. Consider our 900 MHz example above. Had an SMRA been used, whichever of Bidder B and C was considered to have the weaker value for a marginal lot would have had a very strong incentive to demand reduce and end the auction immediately, leading all bidders to pay the zero reserve.

Of course, bidders in CCAs might also benefit from demand reduction. However, the pricing rule tends to undermine any attempt to broker tacit coordination. Specifically, bidders are very reluctant to surrender excess demand for fear that rivals may not reciprocate. With auctions with large numbers of lots, it seems possible that bidders might offer small reciprocal reductions over many rounds. We've modelled this in mock auctions and have seen some evidence of such behaviour in real auctions (it is possible if aggregate demand data is revealed). However, whereas in SMRAs, demand reduction may be brokered at low prices, in CCAs, we've observed that such reductions often only happen as bidders reach or surpass actual incremental valuations, and are difficult to distinguish from straightforward bidding.

Summary: The desire to achieve good relative outcomes in a CCA often creates powerful incentives for overbidding. This can lead to bidders driving up prices well below the market level that would occur with straightforward bidding. As the incentives for overbidding are linked to the predictability of demand, this may lead to huge variance in the clock prices between bands in a multi-band auction.

2.5. Strategic investment incentive

A basic premise behind straightforward bidding in a CCA is that the valuations of a particular bidder are based on intrinsic value. In a spectrum auction context, this means that they are independent of the amount of spectrum other bidders win, and the distribution of spectrum between rival bidders. In multi-band auctions, where a larger amount of spectrum by value is available, bidders could in theory have strategic investment incentive to foreclose downstream competition by bidding above intrinsic value.

Ofcom provides a definition of the strategic investment incentive:¹²

“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 (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). 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.”

We note that such a strategic investment incentive is independent of the auction format; it applies to the SMRA format as well as the CCA format. Also, in practice, it is difficult to draw a clear distinction between intrinsic value and strategic investment value, as most valuation models will have a market share dynamic built into the model, and it is not always

¹² August 2014 Consultation, at §A7.87.

straightforward to distinguish between gains associated with offering a better service and gains associated with having rivals who are capacity constrained.

Some auctions are more vulnerable to foreclosure than others. In order to effectively foreclose the market, two factors have to be present: (i) a large proportion of all available mobile spectrum has to be included in the auction (measured by value), and (ii) spectrum caps have to be relatively lax so bidders are allowed to acquire large quantities of spectrum, thereby foreclosing the market. In addition, if the existing distribution of spectrum outside the auction is already highly asymmetric, then this may increase the likelihood of such opportunities.

Figure 2.1 below illustrates the size of these two factors in eight recent European 4G auctions that used the CCA format while Figure 2.2 illustrates the combined effect of the two factors. Not all bands are equal, so in this simple analysis we account for that by using a weighted value of spectrum.¹³

¹³ Specifically we use the relative values of different spectrum bands as set out by Ofcom in its consultation of UK annual licence fees: 800MHz: 33; 900MHz: 23; 1800MHz: 13; and 2600MHz: 6. For 2.1GHz, we interpolate a ratio of 10. Note our use of these values is for illustrative purposes and does not represent any endorsement of the values, which are subject to consultation.

Figure 2.1: Factors that affect potential to foreclose market¹⁴

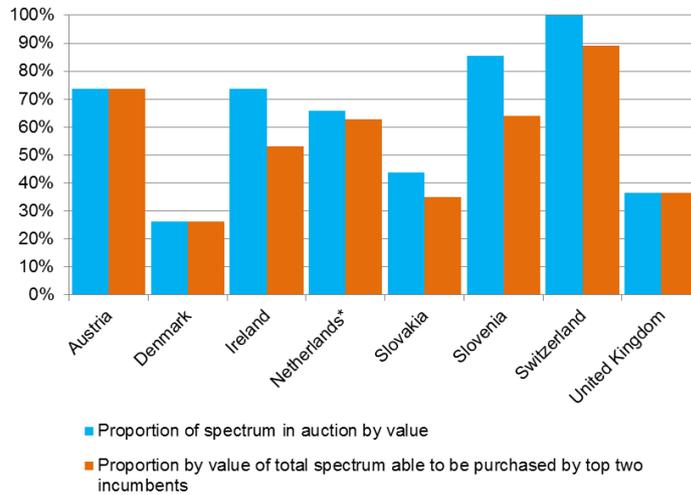
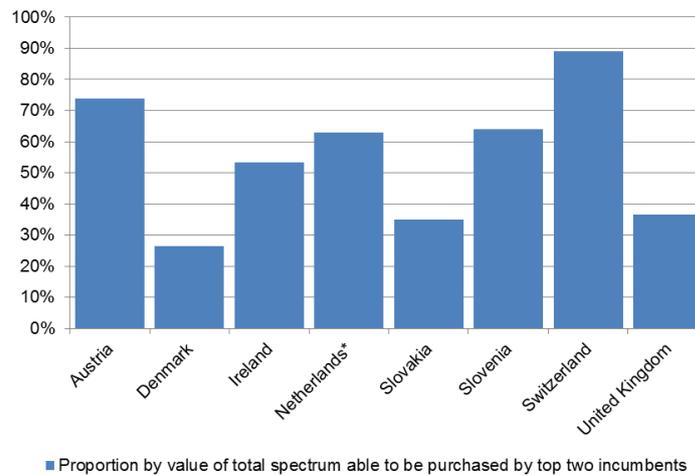


Figure 2.2: Potential to foreclose market



It is evident that the two auctions that had the largest foreclosure potential were Switzerland and Austria. The Netherlands also features prominently. All three awards featured aggressive

¹⁴ For the purpose of this analysis we have used the relative values of different spectrum bands set forth by Ofcom (800MHz: 33; 900MHz: 23; 1800MHz: 13; 2.1GHz: 10 and 2.6GHz: 6). Not all bands are equal, and in this simple analysis we account for that by using a weighted value of spectrum, using Ofcom’s relative values.

bidding during the clock rounds driven either exclusively or primarily by competition between three incumbent bidders. Furthermore, Austria and the Netherlands were the two highest priced auctions in Europe. Given the lack of public bid data or access to bidder valuations, it is impossible to prove whether any bidders did engage in strategic bidders, but the very high prices for some of these auctions in the context of low participation at least implies this is a real possibility.

Summary: Strategic investment incentives have the potential to distort bidding behaviour in spectrum auctions. Such incentives are most likely to occur in large multi-band auctions with lax spectrum caps. If bidders bid on such a basis, price levels in spectrum auctions may be inflated to a level that exceeds market prices (based on intrinsic valuations).

3. Extent to which prices in recent spectrum auctions have been affected

In this section, we explore to what extent prices in recent spectrum auction have been affected by the factors we identified in section 2 above as reasons for deviating from straightforward bidding. In our experience, incentives to deviate from straightforward bidding are usually very specific to local circumstances and may vary greatly from bidder to bidder. Our view is that budget constraints to some extent, and the desire for a good relative outcome to a larger extent, have had a significant impact on the outcome of many recent 4G auctions using the CCA format. In particular, we observe that, in multi-band auctions, these strategic incentives often lead to inflated prices in the clock rounds relative to true market value, but that the level of price inflation may vary significantly. These price distortions also affect supplementary bid outcomes, but the distortions between bands are not always obvious at this point given that bidder's pay a package price not an individual band price.

We discuss incentives in three particular CCAs: the Irish 4G Auction (2012), the UK 4G Auction (2013), and the Austrian 4G Auction (2013). These three examples are particularly

relevant to Ofcom's consultation on annual licence fees (ALFs) for 900 MHz and 1800 MHz. To determine ALFs, Ofcom (a) imputes band prices for 800 MHz and 2600 MHz using the bids from the UK auction; and (b) uses European auction benchmarks to estimate the relative value of 900 MHz and 1800 MHz, when compared to 800 MHz and 2600 MHz. It places particular weight on the results of the Irish and Austrian auctions as so-called "Tier 1" evidence points. For all three auctions, Ofcom has argued that there is no strong evidence to suggest that absolute relative prices were significantly affected by strategic bidding.¹⁵ We strongly disagree with this conclusion, although the extent to which prices were likely distorted varies greatly for each auction.

3.1. The Irish 4G Auction (2012)

The Irish 4G auction was one of the earliest multi-band CCAs, with three bands for sale: 800 MHz, 900 MHz and 1800 MHz. Each band included both short term (2013-13) and long term (2015-2030) licences for sale. For ease of presentation, our analysis focuses on the long term licences, but the arguments regarding strategy also hold for the short term licences.

The auction took place against the following background and rules:

- There were four incumbent bidders, with a clear hierarchy with respect to market share: (1) Vodafone; (2) Telefonica; (3) Meteor; and (4) H3G.
- A very high proportion – over 70% – of total FDD spectrum value was at stake. However, there were relatively tight spectrum caps: 2x20 MHz across the 800 MHz and 900 MHz bands; and 2x50 MHz across all three bands.

¹⁵ Ireland: Annual licence fees for 900 MHz and 1800 MHz spectrum: further consultation (August 2014 Consultation), at §3.51; Austria: 2014 Consultation, at §A8.50, and February 2015 Consultation, at §3.54.A; UK 4G: Annual licence fees for 900 MHz and 1800 MHz spectrum: Provisional decision and further consultation (February 2015 Consultation), at §2.142.

- To protect their legacy networks, Vodafone, Telefonica and Meteor all predictably needed to purchase at least 2x10 MHz at 900 MHz and 2x15 MHz at 1800 MHz.

The tight spectrum caps effectively ensured that all four bidders would win some spectrum. In particular, two bidders could not buy more than about 50% of the spectrum by value, effectively precluding a strategic investment strategy.

The outcome at 900 MHz was predictable, owing to the legacy requirements of the three largest operators. H3G had no legacy 900 MHz operations, so predictably had a much lower value for a second lot of 900 MHz than its rivals. At 800 MHz, it was predictable that the two largest operators would be strong enough to secure 2x10 MHz, but it was unclear if Meteor would have enough budget or value to outbid H3G for 2 lots; the alternative outcomes being H3G securing two lots, or Meteor and H3G taking one lot each. At 1800 MHz, it was predictable that Vodafone would secure at least 2x20 MHz and the other three operators would secure at least 2x15 MHz but ambiguous how the residual would be distributed.

Although H3G was expected to be the weakest bidder, the spectrum caps placed it in a strategically advantageous position. In the absence of a 5th bidder, it was de facto guaranteed to win one 900 MHz lot at reserve price. Furthermore, as its rivals' values for a 2nd lot were predictably much higher, it could afford to overbid for a second and third block of 900 MHz, thereby imposing budget pressure on its three rivals. Such a strategy is clearly sensible, as it would increase its chance of drawing concessions at 800 MHz and/or 1800 MHz if rivals are budget constrained. If unsuccessful, it would at least allow it to set higher prices for rivals, thereby improving its relative outcome when compared to a straightforward bidding strategy.

Our view that H3G engaged in strategic bidding cannot seriously be disputed by anyone with knowledge of what happened in the clock rounds. [X].

In contrast to H3G, the other bidders were highly constrained in their bidding options. Given the spectrum caps, the only scope for meaningful deviation from straightforward bidding was

to overbid for 1800 MHz. In particular, certain bids for larger amounts of spectrum at 1800 MHz were unlikely to win but had the potential to generate higher opportunity cost for rivals. For the other incumbents, this was the only way they could apply any pressure on H3G to offset their strategic advantage at 900 MHz.

The auction outcome, summarised in Table 3.1, is entirely consistent with bidders acting on these strategic incentives for over-bidding at 900 MHz and 1800 MHz. Vodafone, Telefonica and Meteor all won larger spectrum portfolios than H3G but paid between 220% and 175% of H3G's price, consistent with H3G imposing high opportunity cost in both the 800 MHz and 900 MHz bands. However, H3G paid a price significantly above reserve, indicating that it faced substantial opportunity cost for winning 4 lots of 1800 MHz spectrum; as Telefonica paid rather less than Meteor for the same long-term spectrum endowment (and a slightly larger short-term endowment) it is reasonable to suppose that most of this opportunity cost resulted from unsuccessful Telefonica bids for residual spectrum. There is no indication of bidders having been budget constrained, although this cannot be ruled out.

Table 3.1: Outcome of Irish CCA (2012)

	800MHz (2013-2030)	900MHz (2013-2015)	900MHz (2015-2030)	1800MHz (2013-2015)	1800MHz (2015-2030)	Price
Vodafone	2x10	2x10	2x10	2x15*	2x25	€281m
Telefonica	2x10	2x10	2x10	-*	2x15	€225m
Meteor	2x10	2x5*	2x10	2x10*	2x15	€244m
H3G	-	2x5	2x5	2x10	2x20	€105m
Total	2x30	2x30	2x35	2x35	2x75	€855m

* Vodafone, Telefonica and H3G already owned licences to 2015 in these bands.

We conclude that the Irish auction was affected by strategic incentives to overbid in the context of a CCA. However, it is ambiguous whether this had any impact on allocation.

It is rather more likely that strategic bidding affected prices. No band specific prices or bid data is available for Ireland. However, in its ALF consultations, Ofcom uses estimated band-

specific prices based on information provided by Vodafone and the Irish regulator, Comreg.¹⁶ Telefonica has also stated that “the numbers presented are credible as an indicator of relative prices across bands”.¹⁷

It is highly likely that clock prices in the 900 MHz and 1800 MHz bands were inflated beyond the market price, owing to strategic price driving. However: at 900 MHz, tight spectrum caps may have precluded incumbents from targeting a 3rd lot, so it is ambiguous how much the price actually rose beyond market value; and at 1800 MHz, greater uncertainty over the outcome may have served as a constraint on the level of price driving. Meanwhile, at 800 MHz, there was vigorous and relatively straightforward competition. On balance, the distortion to relative prices may therefore have been quite modest.

In its 2nd ALF consultation, Ofcom concluded that Irish price ratios were a Tier 1 benchmark with a risk of over-statement. This is entirely consistent with the evidence regarding strategic bidding. We struggle to understand Ofcom’s rationale for revising this assessment to risk of over- or understatement in its 3rd ALF consultation. With respect to the benchmark 900 MHz price for Ireland, Ofcom says “*we now consider there is also a risk that it understates market value, as operators may have accommodated the non-incumbent holder of 900 MHz spectrum (H3G) in the newly available portion of the band*”. In our view, this analysis must be wrong as accommodation would require that at least one of Vodafone, Telefonica or Meteor to drop demand for low band spectrum, but they each bid to the cap at 800 MHz and 900 MHz throughout the auction. Furthermore, as presented above, there is clear evidence that H3G bid strategically for additional 900 MHz spectrum.

¹⁶ Ofcom Consultation, 10 October 2013, p. 98. According to ComReg, the percentage of prices that Ofcom attribute to different bands are “reasonable indications” “within a couple of percentage points.”

¹⁷ Telefonica response to 1st ALF consultation; paragraph 165.

3.2. The UK 4G Auction (2013)

The UK 4G auction had three bands for sale: 1800 MHz, 2600 MHz paired and 2600 MHz unpaired. The available band plans were conventional but the structure of the CCA had four unusual features: a dynamic spectrum set aside for smaller bidders; differential spectrum caps based on spectrum holdings outside the auction; an option to bid for low power spectrum in the 2600 FDD band on a shared basis; and large differences in eligibility points between bands.

The auction took place against the following competitive background:

- There were seven bidders, but only the four incumbents competed for 800 MHz spectrum. There was a strong 5th bidder (BT) for 2600 MHz spectrum.
- Only H3G qualified for the set aside, meaning it was assured to win one lot of 800 MHz or 4 lots at 2600MHz paired, potentially at reserve depending on its bids. Its preference between these options was ambiguous.
- Vodafone and Telefonica owned the entire 900 MHz band. However, they also had predictable strong demand for 2x10 MHz at 800 MHz in order to roll out LTE using the 900 MHz base station network. Uniquely, these two bidders were also capped at 2x10 MHz in the 800 MHz band.
- EE's demand for additional spectrum was ambiguous, as it already held almost 50% of spectrum in the 1800 MHz and 2100 MHz bands. It was subject to a cap of 8 lots (2x40 MHz) across the FDD bands but could bid for up to 2x20 MHz at 800 MHz.

At first glance, the auction does not look particularly vulnerable to strategic investment, as the proportion of spectrum available by value is relatively modest by European multi-band auction standards. However, given the four-player market and highly asymmetric structure of existing spectrum holdings, the UK was arguably more at risk of such behaviour than other countries. Indeed, at 800 MHz, Ofcom felt compelled to cap Telefonica and Vodafone to prevent an outcome in which they acquired all the sub 1GHz spectrum, and also to create a set aside to

protect the fourth incumbent. It also placed a cap on total spectrum holdings, but this was quite lax compared to its other measures, as it in theory allowed two operators (e.g. EE and Vodafone) to acquire up to 89% by value, including existing holdings.

The very large bids that EE placed for incremental amounts of 2600 MHz paired spectrum have led to speculation that EE was bidding based on a valuation model that included a strategic investment premium.¹⁸ Certainly, it is difficult to rationalise how EE's marginal value for its 5th and 6th lots of 1800 MHz spectrum could have been three times that of Vodafone (which placed the highest bids in the auction)¹⁹, unless their valuations were based on fundamentally different assumptions. EE has stated that all its bids were based on intrinsic value²⁰ but this tells us little, as this does not preclude the possibility that their valuation model had very aggressive assumptions about market share gains associated with changes in spectrum holdings. In this context, Ofcom's conclusion that EE did not bid based on strategic investment²¹ is certainly too strong and could be completely wrong.

Whereas there is ambiguity over the extent to which strategic investment may have affected bids, it is widely recognised that bidding in the auction was affected by strategic bidding and by

¹⁸ February 2015 Consultation, at §2.138.a, Ofcom writes "A possibility for strategic investment, consistent with arguments put forward by Vodafone, relates to EE's incremental bid value of £35.3m per MHz in its winning bid for its first 2x5 MHz of 800 MHz in a package with 2x35 MHz of 2.6 GHz (see the first column in the bottom row of Table 2.4), which took EE up to the limit of the overall spectrum cap."

¹⁹ A list of all bids submitted in the auction is available at <http://stakeholders.ofcom.org.uk/spectrum/spectrum-awards/awards-archive/completed-awards/800mhz-2.6ghz/auction-data/>. EE submitted supplementary bids with incremental values of up to £156.7 per lot for incremental 2600 MHz spectrum above the standard portfolio of 4 lots. In contrast, Vodafone's bids reveal an incremental value of only £53.7m per lot.

²⁰ See EE's Letter to Ofcom, 13 November 2014 (responding to an Ofcom letter of 28 October 2014). http://stakeholders.ofcom.org.uk/binaries/consultations/annual-licence-fees-further-consultation/Letter_to_Ofcom_from_EE.pdf

²¹ February 2015 Consultation, at §A6.153, Ofcom writes "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."

budget constraints. In particular, based on public information and information that Telefonica has given us permission to reveal:

[REDACTED]

In responses to Ofcom's consultation on ALFs, various stakeholders have also alleged that bidders, in particular EE, engaged in strategic price driving behaviour.²² This is hard to prove based on the bid data alone, but is certainly plausible given the incentives that bidders had going into the auction and what happened in the auction.

During the clock rounds, both EE and H3G had obvious incentives to bid each for four lots of 800 MHz, so as to drive up the price of this band, potentially weakening Telefonica and Vodafone as competitive forces at 2600 MHz. Such a package was clearly unwinnable at prices bid in the auction, as evidenced by Telefonica and Vodafone's predictably high supplementary bids to secure 2x10 MHz each. The extent to which EE and H3G may have deliberately overbid is unknown, [REDACTED].

The peculiar eligibility point structure also created a sequential process to the auction that may have further encouraged strategic play. Once EE and H3G dropped demand from 800 MHz to 2600 MHz, they could not return to 800 MHz, but any price increases subsequently imposed on 2600 MHz bands could, in theory, be added to their bids for 800 MHz in the supplementary round. This created potential incentives for EE and H3G to overbid for large quantities of 2600 MHz lots. Meanwhile, the only way Vodafone and Telefonica could impose any opportunity cost on EE was to bid strongly for 2600 MHz, so these two bidders also had incentives to overbid for 2600 MHz.

²² February 2015 Consultation, at §2.138.b, Ofcom writes "A suggestion of price driving put forward by H3G, Telefónica and Vodafone relates to EE's incremental bid value of £32.63m per MHz for a third and fourth 2x5 MHz lots of 800 MHz in addition to a package of 2x10 MHz of 800 MHz and 2x20 MHz of 2.6 GHz (which we used as our proposed market value for the 800 MHz band in the August 2014 consultation)."

These incentives for overbidding fits with the narrative of the UK clock rounds, in which each band was bid up in sequence to high prices, followed by sudden large drops in demand. However, a by-product of this aggressive competition was that the auction ended with many numbers of unsold lots. Given that the final clock round allocation was clearly not a sensible allocation outcome, all bidders faced huge uncertainty over what spectrum packages they might actually win.

The auction outcome is illustrated in Table 3.2. One notable feature is that total revenues of £2.34m were considerably lower than the value of the lots at final clock prices at £3,97m. It is typical in a CCA that winning bidders pay prices below final clock round levels, owing to the second price rule, but this drop is particularly large. By implication, it means that bidders did not impose the full level of opportunity cost for losing incremental spectrum that their clock rounds bids implied they could do.

Table 3.2: Outcome of UK CCA (2013)

	800MHz	800MHz (coverage)	2.6GHz (paired)	2.6GHz (unpaired)	Price
EE	2x5	-	2x35	-	£589m
H3G	2x5	-	-	-	£225m
Niche	-	-	2x15	20	£186m
Telefonica	-	2x10	-	-	£550m
Vodafone	2x10	-	2x20	25	£791m
Total	2x20	2x10	2x70	45	£2,341m

There appear to be a number of countervailing forces at work. Firstly, it appears that H3G and EE significantly overbid for 800 MHz spectrum in the clock rounds, but did not follow through with these bids in the supplementary round. As a result, the 800 MHz clock round price may have risen to a level significantly above market value, but the real opportunity cost as expressed in EE's supplementary bids was much lower. More generally, the high level of unsold lots may have discouraged price driving strategies in all bands in the supplementary

round, given the potential risk of winning unwanted lots. Secondly, H3G deliberately manipulated in bids to secure the set aside but in the process sacrificed options, whether strategic or real, to impose greater costs on rivals. Thirdly, the threat of even higher bids at 800 MHz than in the clock rounds (which in fact never materialized) neutered Telefonica as a competitive force at 2600 MHz.

The implications for allocation and pricing are highly ambiguous. It is apparent that there were strong strategic incentives for price driving in the clock round but off-setting incentives in the supplementary round. It is also possible that EE's bids were based on valuations that incorporated large market share gains as a result of rivals winning less spectrum, an approach that others may consider strategic investment rather than intrinsic valuation.

3.3. The Austrian 4G Auction (2013)

The Austrian 4G auction had three bands for sale: 800 MHz, 900 MHz and 1800 MHz. The available band plans were conventional. The CCA rules were similar to the UK, but with a more conventional eligibility point structure. One significant different from other CCAs was that the Austrian regulator, RTR, initially chose to hide aggregate demand in the clock rounds, although it changed its approach during the auction in response to very high auction prices.

The auction took place against the following competitive background:

- Only the three incumbent bidders participated. There was a clear hierarchy amongst these bidders: (1) Telekom Austria; (2) T-Mobile; and (3) H3G. Telekom Austria and T-Mobile were sufficiently strong that they predictably would not settle for a package of less than 2 lots in each of the 800 MHz and 900 MHz bands, and 4 lots at 1800 MHz. H3G was a less known entity, being recently formed from a merger of the two smaller operators, but also with predictable demand of at least 2x20MHz at 1800MHz.
- The spectrum caps were exceptionally lax when compared to other European countries. Each bidder could acquire up to 2x35MHz across the 800 MHz and 900 MHz bands and

2x70 MHz across all three bands. This meant that in theory two operators could acquire all the available spectrum, amounting to around 74% by value.²³

- In order to protect their legacy operations, each operator likely had irreducible demand at both 900 MHz and 1800 MHz. For the auction dynamics, this was most relevant for 900 MHz, where Telekom and T-Mobile predictably needed at least 2x10 MHz each, and H3G needed at least 2x5 MHz.

With only three operators participating, it is apparent that there was potentially plenty of spectrum for each to walk away with strong footprints. Had the RTR used an SMRA format, a shared outcome at low prices might well have occurred, as the incentives for demand reduction by all parties would have been strong. The actual auction outcome is illustrated in Table 3.3. The prices paid by each operator are highest on a per MHz/pop basis of any auction in Europe, making Austria an exceptional high-price outlier amongst European 4G auctions.²⁴

Furthermore, the strongest operator, Telekom Austria, won an exceptionally large footprint by European standards, whereas the weakest operator, H3G, won an exceptionally small footprint for a 3rd ranked operator.

Table 3.3: Outcome of Austrian CCA (2013)

	800MHz	900MHz	1800MHz	Total
Telekom Austria	2x20	2x15	2x35	€1,030m
T-Mobile	2x10	2x15	2x20	€654m
H3G	-	2x5	2x20	€330m
Total	2x30	2x35	2x75	€2,014m

²³ See Figure 2.2

²⁴ See Falk and Marsden, Annex I: "NERA response to Ofcom comments on our paper: Review of country benchmarks used for setting lump sum values for UK 900 MHz and 1800 MHz".

At first look, this aggressive auction outcome looks surprising, given the low participation level and comparison with other European awards. However, it can be readily explained by the incentives for bidders to deviate from straightforward bidding based on intrinsic valuations associated with the CCA in this specific competitive context.

Firstly, it seems plausible that bid values were distorted upwards owing to strategic investment incentives. In the Austrian auction, the two larger operators could in theory acquire almost all the available spectrum in the auction, amounting to up to 74% of all FDD spectrum in Austria, measured by value. Moreover, two bidders would not need to actually take all of this spectrum in order to constrain the third player from a capacity perspective. Accordingly, unilateral foreclosure strategies based on the minimum likely demand of the other strong incumbent may have also been possible (e.g. by taking 4 lots of 800, 3 lots of 900 and up to 7 lots at 1800 MHz). Under these circumstances, it is entirely plausible that the two larger bidders could construct business cases for bidding above intrinsic value.

Secondly, as in Ireland, H3G had strong incentives to overbid for 900 MHz. H3G likely only wanted one or two lots at 900 MHz, given its limited legacy requirements. In contrast, its two rivals, Telekom and T-Mobile predictably had an irreducible demand of 2 lots each and high values for a third lot. Accordingly, any bid by H3G for 4 out of 7 lots at 900 MHz had no likelihood of winning, and even bids for 3 lots were probably safe up to very high price levels. Moreover, by putting opportunity cost price pressure on the 900 MHz band, H3G could increase its chances of being accommodated with 2 lots at 800 MHz.

These two incentives, for strategic investment and over-bidding, may have reinforced each other. If H3G feared being squeezed out by bids based on strategic investment, its only serious counter weapon is its ability to exploit its rival's predictable demand at 900 MHz becomes. For Telekom or T-Mobile, strategic investment could provide a valuation rationale to support price-driving strategies.

Thirdly, the lack of any aggregate demand data in the early clock rounds effectively removed any scope for bidders to back down from aggressive overbidding. To protect themselves against a bad relative outcome, bidders had to assume that rivals were bidding aggressively and that recusing demand would put them in a less favourable position. By the time the RTR changed its policy, and started to reveal demand data, bidders may have already been committed to these aggressive approaches.

The lack of public bid data means that allegations of strategic bidding in the Austrian auction cannot be verified from the auction results. However, there is direct evidence from the bidders that they believe that the auction process was flawed and that prices exceeded market value owing to incentives for over-bidding:

- Telekom Austria (TKA): Under a slide entitled “*The Combinatorial Clock Auction Format is Highly Complex and Creates Partly Undesired Incentives*”, Telekom states that “*Each bidder has a high incentive to bid on much more spectrum than its real demand and thus to reduce its demand late to influence the price of rivals*”.²⁵
- T-Mobile: “*If one of the three operators was unable to afford spectrum, they would not be able to provide 4G services, and we came very close to that scenario. Therefore, the prices set are at the market value of the entire company, rather than the market value of the spectrum.*”²⁶
- 3 Austria: “*For the industry as a whole, however, this auction result is a disaster...*”²⁷
“*The auction process was illegal in form and in substance. 3 Austria was considerably*

²⁵ Telecom Austria Group, Results of the Austrian Spectrum Auction, October 21, 2013, p. 5.

²⁶ Telecoms.com, 28 November 2013, <http://www.telecoms.com/201711/t-mobile-austria-confirms-intent-to-appeal-auction-results/>.

²⁷ Quote from Jan Trionow, CEO of 3 Austria, in European Communications, 23 October 2013, <http://www.eurocomms.com/industry-news/49-online-press/9370-austrian-operators-slam-having-to-spend-2-billion-on-4g-lte-spectrum>.

harmful. To simply accept this would be irresponsible.”²⁸ “Jan Trionow, CEO of H3G, described the auction as a ‘disaster for the industry’ because the high pricing is likely to see rural rollouts abandoned”.²⁹

Furthermore, in a press release that provides qualitative overview of the bidding behaviour of the three participating bidders, the RTR – which uniquely has access to the full data set – argues that, in the supplementary round, bidders submitted bids on very large packages that were unlikely to win, and that these bids were effective in raising the prices that other bidders had to pay:³⁰

“The three bidders actually submitted a total of more than 4,000 supplementary bids. More than 65% of these supplementary bids were submitted for the largest permissible combinations of frequency blocks, with a share of some 50% of available frequencies. In addition, the bidders utilized almost to the full the price limits that had applied to these large packages during the sealed-bid stage. ... These supplementary bids submitted on large frequency packages had a significant effect on the prices offered by the other bidders. At the same time, such bids generally only have a marginal likelihood of winning out in the end. If these bids for very large numbers of frequencies had been ignored when determining the winners and prices, the revenue from the auction would have settled at a level of about EUR 1 billion”.

²⁸ Quote from Jan Trionow, CEO of 3 Austria, Telecoms.com, 28 November 2013, <http://www.telecoms.com/201711/t-mobile-austria-confirms-intent-to-appeal-auction-results/>.

²⁹ Telegeography, 22 October 2013, <http://www.telegeography.com/products/commsupdate/articles/2013/10/22/a1-scoops-half-of-spectrum-spoils-h3g-brands-process-a-disaster-for-industry>.

³⁰ See, <https://www.rtr.at/en/pr/PI28102013TK>

Given these comments by all parties involved, the evidence that the exceptionally high prices were the result of strategic bidding behaviour seems overwhelming. It is inexplicable therefore that Ofcom still does not recognise this in its analysis of the auction, even after three rounds of consultation.³¹

Given the scale of strategic bidding in Austria, it is clear to us that any analysis of the relative prices for bands in this auction is unsafe. Not only were prices driven up in absolute terms, but it is almost certain that relative prices were distorted across bands. In particular, it seems likely that the 900 MHz price was grossly inflated relative to other bands, given incentives for defensive strategic bidding by H3G. This is borne out in the results of Ofcom's linear reference price analysis of the Austrian auction, which extrapolates band specific prices based on actual bid data.³² These results show an implausibly high value for 900 MHz of over 100% of 800 MHz, which is significantly higher than the typical ratio of 60-70%.³³

4. Concluding Remarks

In this paper, we have addressed the question of whether the CCA provides incentives for straightforward bidding in the context of spectrum auctions. Evidence from recent CCAs suggests that bidders often do not bid straightforwardly in practice, and there are a number of possible explanations for this, most importantly budget constraints, preference for good relative outcomes and strategic investment incentives. Each of these factors provides a rationale for deviating from straightforward bidding under certain circumstances.

³¹ For example, at paragraph A8.48 of Ofcom (February 2015), Ofcom says that in relation to the Austrian 4G auction and "suggestions that there were some bids that bidders knew would not win [...] the evidential basis for bidders having such certainty was unclear to us."

³² Ofcom was not actually given access to the bid data. Instead they provided software for RTR to calculate LRPs on their behalf.

³³ See Falk and Marsden, Annex I: "NERA response to Ofcom comments on our paper: Review of country benchmarks used for setting lump sum values for UK 900 MHz and 1800 MHz" for a quantitative assessment of European benchmarks for the ratio of 800 MHz and 900 MHz.

The strategic incentives that matter typically result in over-bidding relative to market value, potentially by a large amount. Moreover, in multi-band auctions, the incentives for overbidding are asymmetric, with some bands likely to have prices pushed up much more than others, depending on the predictability of rival demand. Legacy bands, such as 900 MHz, are particularly vulnerable to overbidding because incumbents typically have irreducible minimum demands.

The issue of over-bidding in a CCA is highly relevant to Ofcom's consultation on annual licence fees (ALFs) for 900 MHz and 1800 MHz. Ofcom places particular weight on the results from the Irish and Austrian 4G auctions as so-called "Tier 1" evidence points. However, both auctions were CCAs and there is strong evidence that outcomes were affected by strategic bidding. For Ofcom's analysis, the fact that bids were distorted is less important than whether relative bids across bands were distorted, as Ofcom relies only on relative not absolute prices for its benchmarks. We find that there is strong evidence that relative prices in Austria were distorted, implying that this is not a good benchmark for other countries. The evidence for distortion in Ireland is much weaker, implying this is a reasonable benchmark.