11. Auction bidding and outcomes

Summary

- Over 20 years of auctions, the UK regulator's process of learning from experiences and adapting its design decisions depending on the circumstances helped to avoid serious mistakes, and the auctions were largely successful in promoting economic efficiency.
- Strategic bidding that could not be deterred by the design choices had more impact on auction prices than on distorting the efficient allocation of spectrum (such as high prices from apparent overbidding in 2000, and low prices from tacitly collusive market division in 2021).
- The surprises compared to pre-auction expectations illustrate the benefits of using auctions to draw on bidders' decentralised information, compared to the regulatory failure risks inherent in administrative allocation decisions.
- One of the range of practical implementation decisions is how the regulator influences the pace of the auction through the schedule of rounds and the size of the price increment between the rounds of bidding. The regulator trades off enough granularity and time for bidders to make decisions for auction efficiency against longer auctions which could reduce output efficiency by delaying the benefits to consumers.
- Trading of spectrum licences can be a supplement or partial alternative to auctions, as in 2021. However, the multilateral process in auctions with a clearinghouse can generally achieve increased economic efficiency.

Spectrum auctions are often unpredictable, and the surprises can be pleasant with attractive results, or they can take the form of undesirable processes, bidding behaviours, or outcomes. The first section reviews the UK experience to draw out valuable lessons for future auctions. The second section then turns to the implementation issues highlighted in the penultimate row of Figure 11.1, exploring in particular how the regulator can manage the pace of the auction. The final section considers how the

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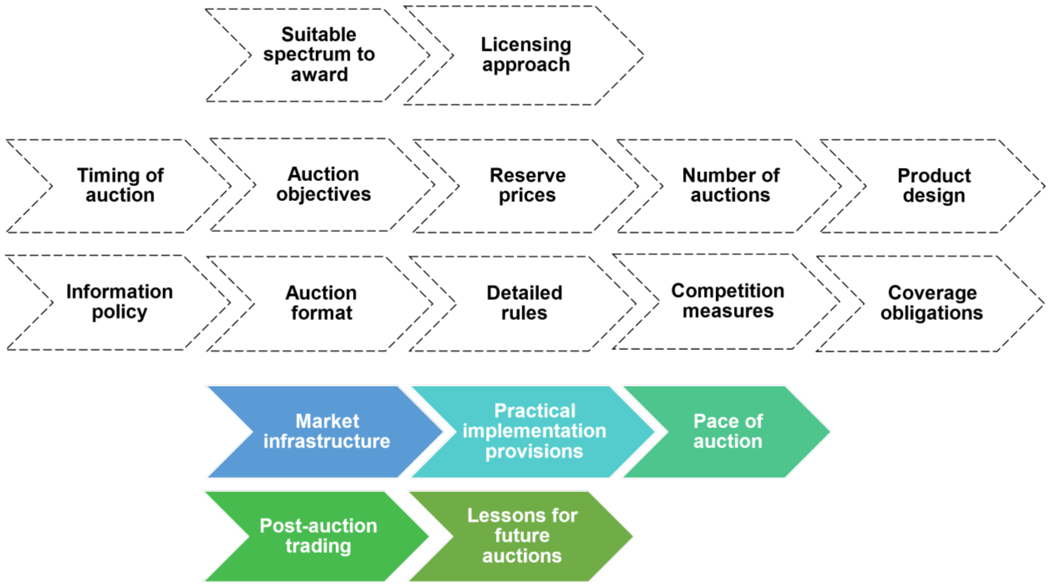
How to cite this book chapter:

Myers, Geoffrey (2023) *Spectrum Auctions: Designing markets to benefit the public, industry and the economy*, London: LSE Press, pp. 197–213. https://doi.org/10.31389/lsepress.spa.k. License: CC BY-NC-ND 4.0

Figure 11.1. Auction decisions covered in Chapter 11



Source: Author.

ownership of licences can change as a result of post-auction trading – sales or swaps – of spectrum between mobile providers, which can provide a helpful supplement to the allocation process in the auction itself.

11.1 Learning lessons from UK auctions

Anyone who has experienced the emotions of being inside the auction room (as I was for the UK's 2013, 2018, and 2021 awards) will appreciate the difficulties of trying to forecast the pattern of bidding by firms, and how the hopes for favourable outcomes can be upheld or dashed by the way that operators choose to bid. The regulator sets the rules and operates the auction, but cannot control how bidders behave, however thorough its planning. This creates considerable potential for surprises to occur and for strategic bidding by companies seeking to exploit loopholes in the auction design. Operators and the regulator can also make mistakes in their bid strategies or design choices. Previous chapters have utilised aspects of the UK's high-stakes auctions as examples to illustrate many of the regulator's design options and decisions, such as setting reserve prices in Chapter 7, choosing the auction format in Chapter 8, and deciding competition measures in Chapter 9. Here I compare how the bidding outcomes matched with the regulator's objectives and expectations, and show how valuable lessons for future auctions can be gleaned from the varied experiences. Annex A provides more detail and evidence to support this commentary, and sets out the full story of each auction.

The revenues generated by auctions are usually prominently reported, and the large disparities between the UK auctions are shown in the first row of Figure 11.2, ranging from £22.5 billion in the 'biggest auction ever' in 2000 to only £1.4 billion in 2018 and 2021. As we shall see, mistakes and

Figure 11.2. Revenue outcomes and rivalry in four high-stakes UK auctions

Issue	3G auction in 2000, 'biggest auction ever'	4G auction in 2013, 'surprises and complications'	PSSR auction in 2018, 'widely seen as successful'	5G auction in 2021, 'short and sweet?'
Revenue	There were very high prices and revenue of £22.5 billion, compared to reserve prices of £0.5 billion.	The revenue of £2.4 billion was well above reserve prices of £1.4 billion.	The prices and revenue of £1.4 billion were much higher than the reserve prices of £0.07 billion, and within an expected range for a competitive auction.	The prices and revenue of £1.4 billion were above reserve prices of £1.1 billion, but still looked low: 45% lower than in 2018 for 5G capacity spectrum; and relatively low by international standards for 5G coverage spectrum.
Rivalry in the auction	There were 13 bidders for 5 licences, contested over 150 rounds of bidding.	The 7 bidders competed, with 5 winners after 52 clock rounds and the supplementary bids in the CCA design.	All 4 incumbents won spectrum after 67 rounds of bidding, and a potential entrant was outbid.	The 4 incumbents were the only bidders over just 4 rounds of bidding for the 5G capacity band, and 11 rounds for the coverage spectrum.

Source: Author from Ofcom auction documents[1] and National Audit Office (2001).
PSSR: Public Sector Spectrum Release.

strategic bidding contributed to the differences, and another factor was the strength of competition in the auction between bidders as indicated in the second row – very strong rivalry in 2000 between 13 firms over 150 bidding rounds, but weak in 2021 between just four operators over 11 rounds. In all cases the regulator successfully sold all the spectrum on offer, partly by consistently setting reserve prices below the spectrum's market value.

However, the revenue raised by an auction does not provide the best basis to judge whether it has been successful, because the outcomes for economic efficiency are usually far more important (see Section 7.2). When assessed on the criteria of auction and output efficiency – see Figure 11.3 – the 2021 auction looks 'short and sweet' despite the low revenue it generated. These criteria also explain why the 2018 auction was 'widely seen as successful', whereas the outcomes of the 2013 auction were more mixed and inconclusive for economic efficiency.

Strategic bidding can come in many forms. It seems to be a phenomenon that each bidding firm claims it would not dream of doing, while often alleging that it is rife in its rivals' bids. Distinguishing strategic from straightforward bidding in practice is sometimes clear, but can often be difficult without knowing the underlying spectrum valuations which are private to the bidders. Many observed bid patterns are potentially consistent with both. There were instances of probable strategic bidding in all four UK auctions as set out in Figure 11.4, but their main impact seemed to be on prices rather than

Figure 11.3. Economic efficiency in UK auctions

3G auction in 2000, 'biggest auction ever'	4G auction in 2013, 'surprises and complications'	PSSR auction in 2018, 'widely seen as successful'	5G auction in 2021, 'short and sweet?'
It is likely that the spectrum was allocated to the highest-value bidders. The set-aside for a new entrant supported strong downstream competition (see Chapter 9). It remains controversial as to whether or not high auction prices delayed operators' 3G investments. But there was no significant evidence of higher consumer prices (see Section 7.2).	The extent of auction efficiency is unclear (e.g. package bids allowed firms to express synergies in their spectrum values, but some bidders may have been adversely affected by the difficulties of bidding with budget constraints – see Section 8.2). Flexible spectrum reservation (floors) supported downstream competition between four credible operators. However, the degree of spectrum asymmetry between operators increased (see Chapter 9).	The outcome looked efficient both for spectrum allocation and to support downstream competition in 4G and 5G services.	The spectrum allocation seemed efficient, and the outcome was also desirable for downstream competition between operators in both coverage and capacity.

Source: Author.

Figure 11.4. Strategic bidding in UK auctions

3G auction in 2000, 'biggest auction ever'	4G auction in 2013, 'surprises and complications'	PSSR auction in 2018, 'widely seen as successful'	5G auction in 2021, 'short and sweet?'
Price driving by BT may have raised the price paid by Vodafone.	Some strategic bids were made, but it is unclear that they affected the outcome.	The possible price driving by H3G in the 4G band may have caused an increase of 50% in the price paid by Telefónica. However, the evidence could also be consistent with straightforward bidding.	There was clear evidence that bidders successfully engaged in market division (tacit collusion) in the 5G capacity band, leading to the low prices paid by EE, Telefónica, and Vodafone.

Source: Author.

the efficiency of the spectrum allocation. Price driving may have *increased* the prices paid by Vodafone for 3G spectrum (2.1 GHz) in 2000 and by Telefónica for 4G spectrum (2.3 GHz) in 2018. And tacitly collusive market division *reduced* the prices paid by all four incumbents for the 5G capacity band (3.6–3.8 GHz) in 2021.

Figure 11.5. Surprise outcomes in UK auctions

3G auction in 2000, 'biggest auction ever'	4G auction in 2013, 'surprises and complications'	PSSR auction in 2018, 'widely seen as successful'	5G auction in 2021, 'short and sweet?'
Very strong competition in the auction and high prices led to the auction revenue far exceeding the pre-auction forecast of only £1–3 billion.	The revenue of £2.4 billion was below the pre-auction revenue forecast of £3.5 billion by the Office of Budget Responsibility (see Section 5.1). The spectrum allocation, including very different amounts won by operators, led to a distribution at the limits of asymmetry set by the safeguard spectrum caps (see Figure 2.5). BT outbid some incumbents to win a material amount of 4G capacity spectrum. The reserved spectrum (floor) decided by auction bidding was the higher-value coverage spectrum (see Section 10.1).	All four incumbents won spectrum which allowed them to launch 5G services (instead of fewer firms winning larger blocks).	Although a risk of market division was evident beforehand, the rivalry in the auction was very weak for the 5G capacity spectrum and limited for the coverage band.

Source: Author.

The desirability of perceived 'surprises' can depend on the eye of the beholder. The intensity of competition in the 2000 auction was reflected in the surprisingly high prices and revenue, many times larger than the official pre-auction forecast shown in Figure 11.5. By contrast, revenue fell well short of the forecast in 2013. The details of the spectrum allocation in 2013 also included other surprises, such as the extent of spectrum asymmetry it caused and the unexpected winners of some of the spectrum. The element of surprise in the allocation in 2018 was desirable for 5G competition between all four operators. These surprises generally indicate the difficulties for the regulator in making accurate judgements about efficient spectrum allocations in administrative processes without the benefit of decentralised market information from operators' auction bids.

Before the 2021 auction the regulator had understood the risk of undesired gaming of the auction by operators via market division in the 5G capacity band, so it was less of a surprise than it might seem to the outside observer. Ofcom chose nevertheless to deploy the SMRA format despite its vulnerability to market division, because the spectrum allocation of an equal split between three operators was still plausibly efficient (see Table 11.3), and it did not have revenue-raising as one of its auction objectives.

The major mistake of overbidding by firms participating in the 2000 auction now seems clear with the benefit of hindsight. It may have arisen from excessive optimism at the time about the commercial attractiveness of 3G services, exacerbated by the pressure of stock market expectations that failing to win a 3G licence could 'ring the death knell' for an operator and force it to exit the mobile market. Figure 11.6 shows that the 2013 auction also saw a few bids that seem like mistakes, although they did not have anything like as large an impact as in 2000.

Figure 11.6. Mistakes by operators and the regulator in UK auctions

3G auction in 2000, 'biggest auction ever'	4G auction in 2013, 'surprises and complications'	PSSR auction in 2018, 'widely seen as successful'	5G auction in 2021, 'short and sweet?'
Overbidding by firms may have been caused by a winner's curse and managerial overconfidence about the commercial prospects of 3G services.	Some firms made unusual bids, such as instances of bids by BT with negative incremental values for more spectrum. Detailed design decisions by the regulator contributed to only limited price discovery in the auction (e.g. activity rules and eligibility points – see Section 8.4 and Annex B3). Not all of the 'bells and whistles' in the complex CCA design turned out to be desirable.	No clear mistakes by the bidders or the regulator.	More revenue could likely have been generated by higher reserve prices for 5G capacity spectrum – however, revenue-raising was not an auction objective. There was potential for a more effective approach to defragmentation of 5G spectrum (see Section 11.3).

Source: Author.

While the regulator's design decisions had some weaknesses, it avoided major mistakes (especially when compared to some flawed auctions elsewhere, which required rule changes during the auctions themselves to enable them to end, as in Finland, Poland, and Portugal). Some commentators could view the design decision for the 2021 auction as a mistake, where the companies outsmarted the regulator. However, as explained in the context of strategic bidding, this criticism would be greatly exaggerated, and the true position is that the bidding and outcome derived much more from differences in objectives between the operators (low prices) and the regulator (economic efficiency, but not revenue-raising).

Valuable lessons for future auctions have been learned from the range of experiences, as set out in Figure 11.7. Operators learned hard lessons about overbidding which they have generally avoided repeating. The regulator similarly learned from admittedly less consequential problems, such as including one too many complications in the design for the 2013 auction. Lessons have also been taken from successes, such as the design choices which facilitated an attractive bidding process and outcome in 2018, as well as the lower-profile achievements from successfully using a second-price rule in assignment stages in 2013, 2018, and 2021 (see Annex A). Another set of lessons relates to benefits from developments in thinking, such as adjusting the balance between simplicity and flexibility in moving from pre-packaged licences in 2000 to more granular, generic lots for later auctions (see Section 7.5), and adapting to changing market conditions through a horses-for-courses approach to fit the auction format to the specific circumstances (see Section 8.5). Finally, the combination in 2021 of a desirable spectrum allocation but tacitly collusive bidding and low prices highlights the importance of understanding the auction's objectives, such as the relative importance of economic efficiency and revenue-raising, when judging the most appropriate design decisions and when assessing its success or failure.

Figure 11.7. Learning from UK auctions

3G auction in 2000, 'biggest auction ever'	4G auction in 2013, 'surprises and complications'	PSSR auction in 2018, 'widely seen as successful'	5G auction in 2021, 'short and sweet?'
Operators learned to avoid overbidding in future auctions in the UK and elsewhere. The regulator moved to more granular, generic lots in future auctions.	The 'heavy machinery' of the CCA format and other complications should only be chosen by the regulator when they are really needed. The second-price rule was effective and far less contentious in the assignment stage to award specific frequencies, than in the main bidding (principal) stage which determined the winners and their spectrum amounts.	The auction design which was successful for both the bidders and the regulator could be deployed again, if future conditions were sufficiently similar.	Despite the regulator using the same essential auction design in 2021 as in 2018, the bidders behaved very differently with far weaker rivalry and much more strategic bidding. Achieving good outcomes for economic efficiency outweighed the undesirable aspects of weak rivalry, tacit collusion, and low prices in the auction.

Source: Author.

11.2 Practical implementation decisions, including the pace of the auction

All auction participants – bidders and the regulator – make a range of implementation decisions in order to take part in the auction. The regulator can influence the pace of the auction, striking a balance between usually modest gains in auction efficiency and risks to output efficiency from delay.

Overview of implementation provisions, including deposits

The regulator provides market infrastructure like the electronic auction system, and provisions for security and confidentiality of information. Before the auction, bidders may be given access to the auction system for training purposes (and for auctions using the more complicated CCA format, the winner and price determination software can be made available, as well as additional arrangements for auction verification – see Section 7.6). The regulator also specifies the application process to participate in the auction, including minimum requirements on each bidder such as being a 'fit and proper person'.

Bidders have practicalities of their own governance structures to check and approve bid strategies before or during the auction. In addition, each participant has to implement the infrastructure of its auction room, including security of physical access and information technology. Preparations for the UK's 2021 auction were affected by Covid-19, and participants may have varied their usual arrangements as a consequence. Some perhaps used virtual (online) auction rooms, given the general resilience of broadband infrastructure even during the pandemic and the complications of social distancing requirements in physical rooms.

For bidders to participate in an auction, they will also need to ensure that financial resources are available to fit their strategy, such as making deposits and paying prices at the end of the auction. Different countries have used a range of approaches for the financial deposit requirements imposed on bidders during the auction. The UK adopted a relatively stringent approach, which is more onerous for bidders. But it helped to ensure that operators were genuinely committed to their bids, and so reduced risks of default. Initial auction deposits were decided by the firms depending on the number of eligibility points they wanted to have for the first round of bidding. For auctions after 2000, bidders could be asked to make top-up deposits during the principal stage up to the amount of their highest exposure so far (such as the bid value of their standing high bids).[2] As an example, top-up deposits were required on four of the days during the two weeks of bidding in the 2018 auction. At the end of the principal stage, bidders were required to ensure that they had on deposit the amount of their principal stage price, and to increase it after bidding in the assignment stage so as to cover their highest assignment stage bids.

Granularity and time for bidder decisions

Auctions for online advertising take milliseconds using automated bidding, but spectrum auctions last for days, weeks, or months. One feature of a successful market from Section 3.1 not fully analysed so far is 'congestion', in this context relating to the granularity of, and time for, bid decisions. With hundreds of millions or billions of pounds at stake, choices about the pace of the auction can support or adversely affect the success of the market. In many rounds, bidders' decisions are routine or pre-planned, but now and then they can have important bids to think through. Operators might be faced with too much congestion, such as insufficient time to make carefully judged bid decisions that need to be cleared through their internal governance. Conversely, auctions can be too slow to resolve and delay putting the spectrum into productive use to deliver new services or quality improvements to consumers.

The pace of the auction is strongly affected by bidders, such as the extent of bidding that made the UK's 2000 auction last much longer than expected, or the weak competition that curtailed the 2021 auction. However, the regulator can affect the pace through its choices. One decision that can lengthen the auction is low reserve prices (see Section 7.3). Another is using frequency-specific instead of generic lots in the product design (see Section 7.4). The auction format can also affect auction duration – for example, SMRAs are slower than simple clock auctions which do not involve standing high bids to be displaced (see Section 8.1). Other important implementation decisions for the regulator are the bid or price increments – the amount by which bids or price increase between bidding rounds – and the schedule of rounds per day.

The choice of bid increment highlights a trade-off between auction efficiency and output efficiency. Discussions of bid increments in the existing literature have tended either to focus on revenue, or a trade-off between auction efficiency and incremental participation costs to bidders and the auctioneer (such as the opportunity cost of time of the bid team, their advisers, and senior executives involved in governance decisions).[3] Such costs are relevant, but the analysis here emphasises the impact on output efficiency of delay in access to the spectrum, which can be especially relevant in particular cases. For example, some operators winning 2.3 GHz and 700 MHz paired spectrum in the UK's 2018 and 2021 auctions started to use it in their networks within a day of the licences being granted (Telefónica and EE).[4]

An example of a long auction adversely affecting output efficiency was Portugal's 2021 auction, which awarded spectrum for 5G services and included set-aside spectrum for new entrants. The pace of the auction was agonisingly slow, finally ending after more than nine months and a record 1,727 rounds of bidding over 201 days.[5] The slow pace derived from the unfortunate confluence of various design features. Bidding started from low reserve prices. From a menu of options, bidders could choose their bid increments as small as one per cent. Granular lots attracted separate bids in an SMRA format, instead of the faster pace with generic lots or a simple clock auction. For example, the 5G capacity spectrum band included 30 lots of 10 MHz each in one group which were close substitutes. When there was not much excess demand, this meant it could take 30 rounds to increase the price by just one per cent on substitute spectrum, through displacing the standing high bidder at the previous price on each of the 30 lots in turn.[6] The incumbents also seemed to have an incentive to delay, because the new entrants would not receive their spectrum to compete against them in the downstream market until the end of the auction. The very lengthy auction delayed the time when Portuguese consumers benefitted from increased mobile competition, improved coverage, and 5G deployment. Portugal was the last country in the European Union (apart from Lithuania) to launch 5G services.[7]

The trade-off between auction and output efficiency for price increments

One side of the trade-off is how the risk of a loss in auction efficiency varies with the size of the price increment. The standing high bid mechanism in the SMRA means that bidders can face different prices in the same round. For example, when two operators are competing, the standing high bidder (S) placed its bids at the price in the previous round. To displace S, a non-standing high bidder (N) has to bid at the current round price, which is higher by the amount of the price increment. This leads to the possibility of an inefficient allocation, if bidder N has a higher value of the spectrum than S, but fails to win because the price increment is too large. The risk is that the price increment overshoots the market-clearing price — in effect, there is congestion because the decisions that the regulator asks bidders to make are insufficiently granular.

A useful approximation of the maximum expected allocative efficiency loss per lot is the price in the penultimate round multiplied by the square of the percentage price increment.[8] Taking the 700 MHz paired band in the UK's 2021 auction as an example, the penultimate round price was £140 million per 10 MHz lot and the percentage increment in the final round was 7.1 per cent. The approximation suggests a maximum expected loss in auction efficiency for the final lot of about 0.5 per cent of the price, or £0.7 million. Another example yielding a similar maximum expected loss is from the UK's 2000 auction—prices were very much higher but offset by a smaller percentage price increment. The penultimate price was £3,970.5 million and the price increment that led NTL Mobile to drop out to end the auction was 1.5 per cent, suggesting an approximate maximum expected efficiency loss of 0.0225 per cent, or just £0.9 million.

The approximation assists sensible regulatory judgements about the size of the price increment and how to vary it during the auction (while recognising that the underlying method has limitations). The examples illustrate that the expected loss in auction efficiency can be made rather small by choosing a suitable price increment later on when there is a greater risk of the auction ending. A common approach is to start with a larger price increment when there is plenty of excess demand, and reduce it in later rounds when excess demand falls. But the first example from the 2021 auction also shows that the expected loss can be small even with a sizeable percentage increment.

The other side of the trade-off is the economic welfare cost of a slower auction in participation costs for bidders and the regulator, and losses in output efficiency from delaying access to the spectrum. In some cases, these losses will be small, for instance the date of the auction may be comfortably in advance of deployment of the spectrum. Such circumstances suggest that a desirable trade-off is a sufficiently small increment to keep a lid on the potential loss in auction efficiency even if it prolongs the auction. However, given the approximation, the price increment does not need to be that small – for example, with a 5 per cent increment the maximum expected loss per lot is only 0.25 per cent of the price. Unless auction prices reach very high levels, this increment is unlikely to give rise to substantial concern. Moreover, there are cases when delay in the auction from an excessively small price increment causes losses to consumers, as in the example from Portugal. If so, a better balance is to maintain a sizeable price increment and allow the auction to proceed more quickly, such as avoiding small increments like 1 or 3 per cent. The marginal gain from improved auction efficiency is likely to be offset by the loss in output efficiency.

Another relevant attribute of the price increment is its predictability for bidders. Depending on their internal governance arrangements, operators may need to plan when to trigger financial arrangements to make top-up deposits, or to engage with their senior executives, for instance at threshold bid amounts. These considerations may depend more strongly on the absolute level of prices, but percentage price increments mean that the absolute size of the increment increases with the price level (unless the percentage increment falls sufficiently quickly). In addition, in the approximation the maximum expected loss in auction efficiency grows with the absolute level of prices, as well as the square of the percentage price increment. For the 700 MHz paired band in the UK's 2021 auction, the regulator set the price increment in absolute terms at £10m per lot throughout the auction, which provided maximum predictability (especially desirable during Covid-19 restrictions). There were also only modest risks of losses in auction efficiency. At the start of the auction, the absolute increment represented 10 per cent of the reserve price of £100 million. As the price increased over the rounds, the associated percentage increment correspondingly fell. According to the approximation, the implied expected loss in auction efficiency per lot was comfortably less than £1m throughout the auction, and it declined over the rounds (because the reduction in the percentage increment was fast enough to more than offset the increase in the price level). In the right circumstances, increments set in absolute monetary amounts can be an attractive approach.

The schedule of rounds per day affects the duration of the auction in addition to the choice of price increment. The range of acceptable number of rounds per day can be influenced by country circumstances, how experienced the bidders are, and the nature of their internal governance arrangements. The schedule can be varied through the auction, depending on the state of play. For instance, the UK's 2018 auction started at five rounds on the first bid day and then moved to seven rounds from day 2. Later in the auction the level of excess demand was lower, so that the auction progressed more slowly (because it took several rounds to displace all the standing high bids at the previous price). From round 47 the schedule was increased to nine rounds per day for the last few days.[9] Portugal's 2021 auction started at four rounds per day, and ultimately increased to twelve rounds per day (after day 120). Some auctions around the world have been run with many more rounds – for instance, Italy's 2011 auction lasted 469 rounds over 22 days, an average of more than twenty-one rounds per day.

The overall pace of the auction

The pace of the auction is affected by a range of levers that the regulator can pull, including reserve prices, lot structure, auction format, price increments, and round schedules. These interact and different combinations can allow the auction to proceed at a reasonable pace. For example, Italy's 2011 auction used small price increments and many rounds, but a large number of rounds per day. There is a regulatory failure risk of a bias towards the pace of the auction being too slow. Operators often prefer a slower and more granular auction which can assist their decisions on bid strategies. The nature of the regulatory process may also incline towards going along with the preference of the company wanting the slowest pace. These are usually entirely legitimate reasons. However, they leave out of the picture the interests of consumers, which may be under-represented in the debate, putting more onus on the regulator to fully reflect the consequences of the pace of the auction for output efficiency.

The overarching framework for decisions about the pace of the auction is a trade-off between *auction* efficiency and *output* efficiency, which very much depends on circumstances so that it is not too fast and not too slow. For auction efficiency, the pace of the auction affects the congestion faced by bidders, both the granularity of their decisions (such as size of the price increment) and the time they are given to make their choices (the schedule of rounds). For price increments, the approximation of maximum expected auction efficiency losses suggests that an increment of 5 per cent is unlikely to lead to a significant efficiency concern unless prices reach very high levels. Although smaller price increments, like 1 or 3 per cent further reduce the expected loss in auction efficiency, the gain is usually modest. There can be an important downside from a slow auction, delaying deployment and deferring consumer benefits from new, better-quality services or increased competition, such as for Portugal's 2021 auction.

11.3 Spectrum ownership changes outside auctions

Auctioned licences in the UK are tradeable, allowing for post-auction adjustments to take place between firms – for example if bidders have regrets, circumstances change unexpectedly over time, or auctions create new opportunities for substitutes or complements. Figure 11.8 shows that there have been few trades of mobile spectrum in the UK where one licensee sells spectrum to another. The small number may reflect barriers to trading, such as transactions costs, coordination failure between linked trades, strategic motivations, and bargaining problems (e.g. arising from market power, asymmetric information, and incentives to hold out). Trades are more common in some other jurisdictions with regional licensing such as the USA, perhaps reflecting greater trading opportunities. Other changes in mobile spectrum holdings in the UK have occurred through mergers between firms – for instance, H3G took over UK Broadband in 2017 and acquired 120 MHz of prime 5G spectrum in the 3.4–3.8 GHz band.

Spectrum defragmentation after the UK's 2021 auction

Mobile operators may decide to swap spectrum between themselves, rather than selling it. Events after the UK's 2021 auction fall into this slightly different category. The swaps took place because of some very specific issues about defragmentation of holdings in the wider 3.4–3.8 GHz band, the primary spectrum for early 5G deployment in Europe. Section 7.4 gave this wider band as an example of sequential awards – the lower part, 3.4–3.6 GHz, was awarded in 2018 and the upper part, 3.6–3.8 GHz, in the 2021 auction because they became available for mobile use at different times. After the 2021 auction, three of the mobile operators had separate blocks wide apart in each of these sub-bands. However, there were technical efficiency gains from defragmenting so that each operator held closer blocks ('proximity'), and potential for further gains from contiguous spectrum holdings.

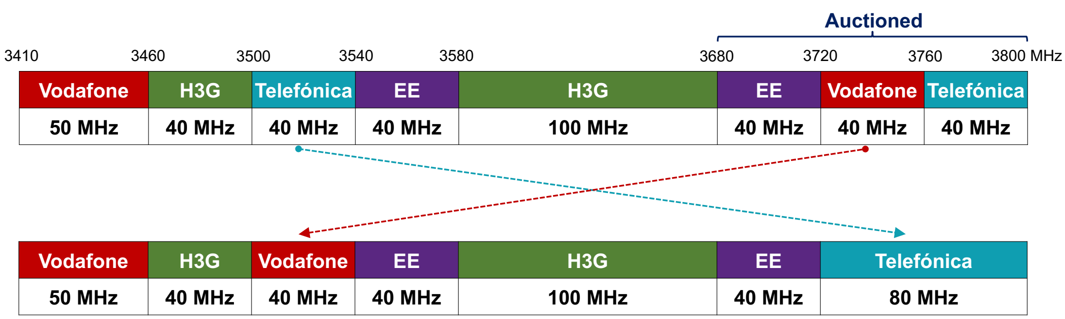
Figure 11.8. Sales of mobile spectrum licences in the UK through trades to operators

Spectrum and year	Description
1800 MHz in 2012	As a condition for approving the merger of Orange and T-Mobile in 2010 to establish EE, the competition authority imposed a spectrum divestment remedy.[10] EE sold 30 MHz to H3G in advance of the 2013 auction (otherwise the spectrum would have been included in that auction).
1.4 GHz (L Band) in 2015	Qualcomm originally won 40 MHz of this spectrum in a 2008 auction for just £8 million. At the time this band was not regarded as being mobile spectrum – the expected use was for mobile TV or digital radio. Qualcomm later re-purposed the spectrum for supplementary downlink (SDL) capacity in mobile networks. It traded 20 MHz each to H3G and Vodafone in 2015. Press reports suggested it earned £200m in revenue from the sales.[11] This episode highlights the distinction between fairness and economic efficiency, because it involved a large multinational company profiting from a public asset, but also resulted in improved efficiency of the spectrum allocation.
2.6 GHz unpaired in 2020	BT won this spectrum in the 2013 auction. Over time, after BT took over EE, it became more valuable for Telefónica which had much smaller holdings of capacity spectrum, leading to mutual gains from an efficiency-enhancing trade.

Source: Author.

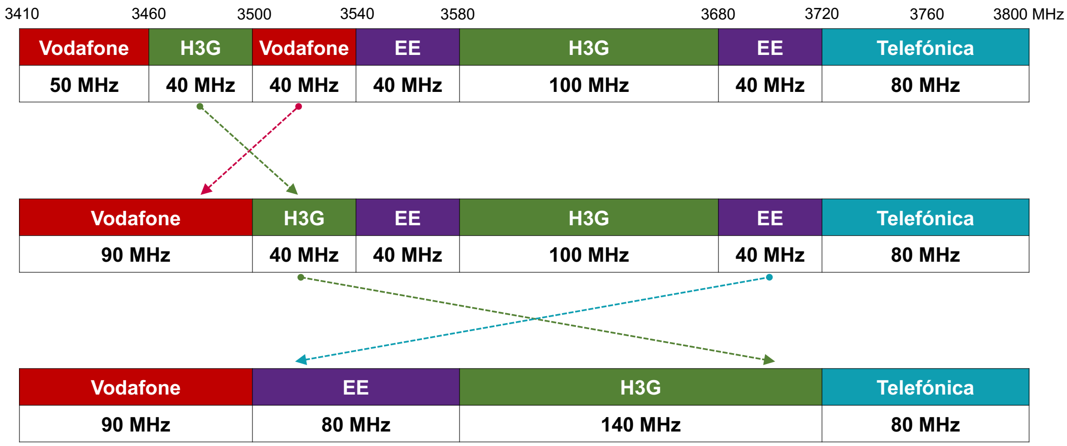
On the day that the 2021 auction ended, two operators (Telefónica and Vodafone) announced their agreement to swap spectrum and reduce fragmentation, a process that the assignment stage in the auction had been designed to facilitate (see Annex A5).[12] The effect of this trade is shown in Figure 11.9, changing the band plan from the immediate post-auction position in the top row to the post-trading situation in the bottom row. At the start, only H3G had 100 MHz of contiguous spectrum. After the swap Telefónica had 80 MHz of contiguous spectrum, and Vodafone's two blocks were much closer together so it could obtain the gains from sufficient spectrum proximity. EE's two blocks were unchanged but close enough for them to get these gains as well.

Figure 11.9. Post-auction spectrum swap between Telefónica and Vodafone in the wider 3.4–3.8 GHz band, achieving contiguity for Telefónica and proximity for Vodafone



Source: Author.

Figure 11.10. Possible further spectrum trades in the wider 3.4–3.8 GHz band to achieve full defragmentation



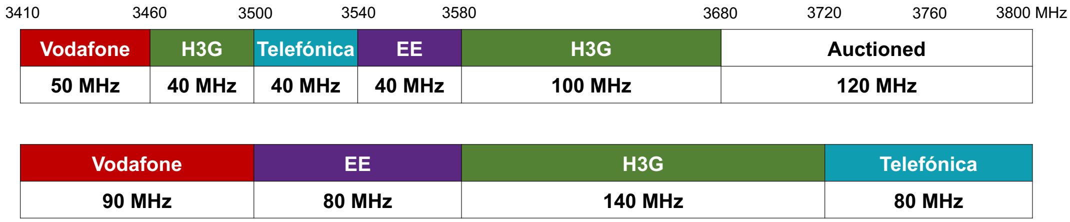
Source: Author.

There could be further gains in economic efficiency from possible further linked trades to lead to full defragmentation, first between H3G and Vodafone, and then between H3G and EE – Figure 11.10 illustrates that these two further swaps could bring all of EE's, H3G's, and Vodafone's separated blocks together to become contiguous. These trades would involve incremental costs for operators to relocate their frequencies to offset against the incremental benefits. Operators could reflect these effects in their trading negotiations. But the risks of a coordination failure or breakdown in bilateral negotiations could get in the way.[13] At time of writing, 18 months after the auction, the further trades and full defragmentation had not occurred.

An alternative approach would have been for the regulator to seek to achieve contiguous holdings for all operators within the 2021 auction itself, through a 'grand assignment stage' for full band reassignment of the wider 3.4–3.8 GHz band. The regulator could have required all holders of pre-existing 3.4–3.8 GHz spectrum to include it in the assignment stage, including both the 3.6–3.8 GHz spectrum won in the immediately preceding principal stage of the auction and operators' pre-existing holdings of 3.4–3.6 GHz spectrum. Bids made by operators could have reflected their preferences for different frequency locations, including avoiding the costs of relocating existing holdings to different frequencies. In principle, this was an attractive mechanism to achieve full defragmentation, deploying a different type of market than trading, a multilateral process with a clearinghouse. That can provide more coordination than bilateral negotiation for trades, especially where – as here – there were multiple linked trades. In a multilateral mechanism the transactions can occur simultaneously, whereas bilateral trading involved a sequential process with the benefits of some trades depending on subsequent swaps also occurring. An illustration of one of the possible outcomes from a grand assignment stage is shown in the bottom row of Figure 11.11 (which is the same as the bottom band plan in Figure 11.10), compared to the pre-auction position in the top row.

The illustration assumes that the same spectrum amounts would have been won in the prior principal stage of the 2021 auction, which is not certain. A further benefit of a grand assignment stage could have been to the competitiveness of principal stage bidding. Without a grand assignment stage, and

Figure 11.11. Illustration of a possible outcome with an alternative approach to achieve full defragmentation via a grand assignment stage in the auction



Source: Author.

relying on post-auction trades for defragmentation, operators knew that acquiring exactly 40 MHz in the 3.6–3.8 GHz band, no more and no less, was important to allow the post-auction swaps shown in Figure 11.9 or Figure 11.10. This is why the allocation of 40/40/40 MHz was such a clear and obvious focal point which facilitated the market division in the auction.

However, a grand assignment stage would have ensured that, whatever the amounts of 3.6–3.8 GHz spectrum obtained in the principal stage, they would form part of a contiguous set of frequencies for each operator at the end of the auction. Bidders could have therefore expressed their underlying values for the spectrum. The strength of the focal point in the 2021 auction would have been reduced. But a significant risk of market division to achieve 40/40/40 MHz would still have remained, reflecting not only its symmetry but also its plausibility as a desired (and efficient) outcome.

A grand assignment stage was debated during the policy development process for the 2021 auction. The regulator accepted that the economic benefits could exceed the costs, but placed weight on some opposing arguments. H3G's potential commercial gain from post-auction trading would have been removed. There could have been an adverse effect on licensees' certainty over their spectrum rights. The alternative policy approach adopted of post-auction trading was less onerous.[14] A grand assignment stage was also contentious with operators, some favouring it and others opposed. It could have been challenged in litigation, causing complication and possible delay.

These counter-arguments to the advantages of a grand assignment stage have weaknesses. The effect on H3G is not an economic efficiency concern. Any effect on future spectrum rights would be mitigated by the very particular distinguishing features of the defragmentation issue in this case. And more than a year after the auction, trading had not achieved full defragmentation.

Conclusions

The UK's high-stakes auctions show varied experiences in revenues, strategic bidding, surprise outcomes, and mistakes. The regulator's careful design choices assisted the auctions to achieve outcomes that were generally desirable for both auction and output efficiency. Valuable lessons for future auctions were learned in attempting to replicate successes and avoid recurring problems. However, bidders also learned from their experiences, so regulators must constantly update their analyses and wherever possible anticipate new problems.

In shaping how auctions develop once under way, the regulator will need to trade off enough granularity and time for bidders to make decisions to promote auction efficiency against longer auctions sometimes reducing output efficiency through delayed benefits to consumers. Where spectrum licences can be sold or swapped outside of the primary allocation in auctions themselves, spectrum trading can be a useful supplement to achieve welfare-improving adjustments to allocations. But the *multilateral* procedure and clearinghouse involved in auctions can generally obtain more for economic efficiency than relying on a process of *bilateral*, uncoordinated trades.

Notes

1 Ofcom's spectrum awards archive: https://www.ofcom.org.uk/spectrum/spectrum-management/spectrum-awards.

2 Deposit arrangements were much more limited in the UK's 2000 auction. Bidders were only required to make an initial deposit of £50 million plus an additional £50 million if their bids exceeded £400 million. The consequence was that the deposit cover (the deposit as a percentage of the bid amount) for most of the auction was very low, ending up at 2.5 per cent or less.

3 For example, Rothkopf and Harstad (1994) consider a trade-off in oral auctions between size of the bid increment and costs of participation and of the auctioneer's time. Milgrom (2004, footnote 10) refers to a trade-off with transactions costs, recognising incumbents' interests in delay only in a later section analysing activity rules. David et al. (2007) examine costs of the auctioneer, revenue, and auction efficiency for online auctions.

4 See O2 'O2's customers are the 'winners' as Telefónica UK makes £500m airwaves investment to further strengthen its network', 5 April 2018, https://perma.cc/2BVD-Y9SJ, and EE 'BT's mobile business EE launches new spectrum into 5G network, as auction concludes', 27 April 2021, https://perma.cc/89B7-HGP5.

5 See ANACOM 'Daily information on the 5G auction', https://perma.cc/6YY8-QFZH.

6 The auction in Portugal started with a stage of bidding between new entrants for set-aside spectrum which lasted for eight days between 22 December 2020 and 11 January 2021. Bidding for unreserved spectrum in the next stage commenced on 14 January and ended on 27 October 2021. The duration of rounds at 60 minutes and the minimum bid increment of one per cent were specified in the auction regulations (see ANACOM 'Regulation no. 987-A/2020, of 5 November', 2020, https://perma.cc/CBF9-LX37). The regulator, ANACOM, attempted to speed up progress by changing the rules twice during the auction (see ANACOM 'Regulation no. 596-A/2021, of 30 June', 2021, https://perma.cc/285X-74PD). The first change enabled a faster schedule of shorter rounds per day, moving from the initial four rounds per day to seven rounds on days 82 to 119, up to 11, and then to 12 rounds from day 121 onwards. Later ANACOM removed the one and three per cent bid increments by raising the minimum bid increment to five per cent from day 180. The 5G capacity spectrum band (3.6 GHz) took by far the longest to resolve, and the final prices in the main lot category were eventually more than eight times larger than reserve prices.

7 See European Commission (2022, p.9) and the announcement of 5G services at NOS 'NOS is the first operator to launch 5G in Portugal', 26 November 2021, https://perma.cc/65DW-AT5X.

8 I was introduced to the approximation while at Ofcom by Paul Milgrom. The intuition can be seen by analogy with the welfare loss from excessive monopoly pricing, the so-called deadweight

loss – see Hines (1999). Its size is related to the square of the price change above the competitive level, because it depends on the magnitude of both the price change and the volume change, and both increase with a larger price difference. For spectrum auctions, the expected loss is the reduction in auction efficiency multiplied by the probability of it occurring, and both are proportional to the price increment. The approximation rests on simplifying assumptions which imply limitations in using it. The underlying theory relates to substitutes with straightforward bidding – see Milgrom (2000). With complements the analysis is more complex, including that the loss in auction efficiency can relate to multiple lots being misallocated. Within-band synergies can mean that the non-standing high bidder reduces demand in a modular amount of several lots, not just a single lot. Another simplifying assumption is that the price increment is sufficiently small that the more efficient allocation is only a slight improvement.

[9] Ofcom (2018a).

[10] European Commission (2010).

[11] See Reuters 'Qualcomm to sell L-Band UK spectrum to Vodafone, Hutchison', 26 August 2015, https://perma.cc/8DNZ-YZTA.

[12] See O2 'O2 & Vodafone customers set to receive 5G boost as companies announce deal to optimise spectrum bands', 27 April 2021, https://perma.cc/ZNE2-6X2F.

[13] Some commentators have also suggested a barrier because administratively set annual fees applied to part of H3G's holdings that would be involved in the trades: see Enders Analysis 'Spectrum trading thwarted: 5G stumbling blocks endure', 3 September 2021, https://perma.cc/B6VP-3MD8

[14] Ofcom (2020a, section 6).

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Note: means an open access publication.

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