

WHAT REALLY MATTERS IN AUCTION DESIGN

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Abstract:

The most important issues in auction design are the traditional concerns of competition policy—preventing collusive, predatory, and entry deterring behaviour. Ascending and uniform-price auctions are particularly vulnerable to these problems (we discuss radiospectrum and football TV-rights auctions, electricity markets, and takeover battles), and a hybrid of the sealed-bid and ascending auctions may often perform better. However, everything depends on the details of the context; the circumstances of the recent U.K. mobile-phone license auction made an ascending format ideal. We also discuss the current 3G spectrum auctions in Germany and the Netherlands.

Auction design is a matter of “horses for courses”, *not* “one size fits all”.

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References

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¹*Disclaimer:* I was the principal auction theorist advising the U.K. government’s Radiocommunications Agency, which designed and ran the recent U.K. mobile-phone license auction. Ken Binmore had a leading role and supervised experiments testing the proposed designs. Other academic advisors included Tilman Borgers, Jeremy Bulow, Philippe Jehiel, and Joe Swierzbinski. *The views expressed in this paper are mine alone.*

The views expressed on past and future radiospectrum auctions in Germany, Holland, and the U.S.A., gold auctions, electricity markets, takeover battles, and football TV-rights auctions are also mine alone.

1. Introduction

Now that many economic markets—from electricity and financial markets to mobile-phone license auctions and business-to-business internet markets—are analysed as auctions, there is a danger that the lessons of traditional economics may sometimes be overlooked.

Most auction literature assumes a fixed number of bidders who behave non-cooperatively. For example, a typical survey (my own¹ is no exception) begins with the revenue-equivalence result and discusses the effects of risk-aversion, correlation of information, budget-constraints, asymmetries etc., with relatively little attention—reflecting the scant literature²—to collusion and entry deterrence. But while the thinness of the auction-theoretic literature on these latter topics may be defensible to the extent general economic principles apply, there is a real danger that they may be underemphasized in applications.

The most important issues in designing auction markets probably remain those with which industry regulators and competition authorities have traditionally been concerned—discouraging collusive, predatory and entry-detering behaviour.³

2. Collusion

While explicit collusion can be a problem, a much bigger concern is “tacit” (and often legal) coordination among firms, just as this is probably

¹Klemperer (1999).

²The most important contributions to the economics literature on auctions are collected in Klemperer (2000).

³In addition to addressing these issues of *conduct*, regulators and competition authorities also analyse the merits of mergers or other changes to market *structure*. Issues of market structure are critical in the special case of designing auctions that create new markets. See [penultimate section].

the greater problem for competition policy given existing law. Multi-unit ascending and uniform-price auctions seem particularly vulnerable to tacit collusion.

In a multi-unit *ascending* auction, bidders can use the early stages when prices are still low to signal their views about who should win which objects, and then, when consensus has been reached, tacitly agree to stop pushing prices up.

For example, in a 1999 German spectrum auction of ten licences, Mannesmann bid a low price for half the licenses and a slightly lower price for the other half. Here is what one of T-Mobile's managers said. "There were no agreements with Mannesmann. But Mannesman's first bid was a clear offer." It seems T-Mobile understood that it could raise the bid on the other half of the licenses slightly, and that the two companies would then "live and let live" with neither company challenging the other on "the other's" half. Just that happened. The auction closed after just two rounds with each of the bidders having half the licenses for the same low price.⁴

Similarly, a 1997 U.S. spectrum auction that was expected to raise \$1,800 million raised less than \$14 million. While the enormous revenue shortfall was surely not all due to "collusion", Cramton and Schwartz (1999) explain how bidders used the final three digits of multi-million dollar bids to signal the i.d. numbers of the areas they coveted.⁵

⁴The auction was a simultaneous ascending auction in which any new bid on a license had to exceed the previous high bid by at least 10%. Mannesman's first bids were 18.18 million DM per MHz on licenses 1-5 and 20 million DM per MHz on licenses 6-10. The point, of course, is that 18.18 plus a 10% raise equals 19.998 \approx 20 which is exactly what T-Mobile then bid on licenses 1-5 in round 2, after which no further bids were made.

The story in this paragraph is from *Frankfurter Allgemeine Zeitung*, 29/10/99, p.13, and Jehiel and Moldovanu (2000). It is my understanding that the bidders' behaviour was entirely legal.

⁵For example, in another auction U.S. West was competing fiercely with McLeod for

By contrast, bidders cannot easily achieve the same coordination in simultaneous conventional *first-price sealed-bid* auctions, in which each object is sold to the highest bidder at the price it bid for that object. In this case, there is neither the opportunity to signal, nor the ability to retaliate against a bidder who fails to cooperate; the low prices in the ascending auction are supported by the threat that if a bidder overbids a competitor anywhere, then the competitor will retaliate by overbidding the first bidder on markets where the first bidder has the high bids.

However, the problem of “implicit collusion” can arise in one special kind of sealed-bid auction, namely a *uniform-price* auction for multiple units of a homogeneous good (e.g. electricity). In a uniform-price auction the price for every unit is set only by the lowest winning bid, so the remainder of firms’ bidding schedules can be used as costless threats that will determine prices only if another bidder deviates from an implicitly-agreed market division.⁶ That is, bidders can tacitly agree to divide up the market at a very favourable

Rochester, MN (license 378). Although most bids were in exact \$1,000s, U.S. West made bids such as \$313,378 in Waterloo, IA, and \$62,378 in Marshalltown, IA, where McLeod had the previous high-bids, together with other similar bids apparently intended to punish McLeod, after which McLeod stopped competing in Rochester. This story is from Cramton and Schwartz (1999). See also “Learning to Play the Game”, *The Economist*, 17/5/97, p. 120.

Additional theoretical literature on the vulnerability of ascending auctions to collusion includes Robinson (1985) and Milgrom (1987) on the single-unit case, and Menezes (1996), Weber (1997), Engelbrecht-Wiggans and Kahn (1998), Ausubel and Schwartz (1999), Brusco and Lopomo (1999) and Cramton and Schwartz (2000) on the multi-unit case. See also Hendricks and Porter (1989).

⁶[Note Y] With many units, the lowest winning bid in a uniform-price auction is typically not importantly different from the runner-up’s bid, so this auction is analogous to an ascending auction (in which every winner pays the runner-up’s willingness-to-pay). The “threats” that support collusion in a uniform-price auction are likewise analogous to those supporting collusion in an ascending auction.

Note that “collusion” in the uniform-price auction is supported even as a static “Nash equilibrium”. See, especially, Wilson (1979), Anton and Yao (1992), and Back and Zender (1993). Implicit collusion is harder if supply is uncertain since this reduces the number of points on the bid schedule that are inframarginal and can be used as threats. See, especially, Klemperer and Meyer (1989), Back and Zender (1993), and Nyborg (1997) and relatedly Back and Zender (1999), McAdams (1998), and Federico and Rahman (2000).

price for themselves by each bidding extremely aggressively for smaller quantities than “its share”, thus deterring other bidders from bidding for more. The U.K. electricity regulator believes this market has fallen prey to exactly this kind of “collusion”.⁷

Again, by contrast, “implicit collusion” is harder in a *discriminatory* auction in which every winner pays its actual bids for the quantity it wins,⁸ so firms cannot use inframarginal bids as costless threats that support the collusive equilibrium. Partly for this reason the U.K. regulator has proposed a set of New Electricity Trading Arrangements (NETA) that will replace the uniform-price auction by an exchange market followed by a discriminatory auction.⁹

Furthermore, although it is easier for firms to collude in any auction that is repeated many times,¹⁰ it remains true that repeated ascending and uniform-price auctions are generally more susceptible to collusion than are repeated sealed-bid and discriminatory auctions.

Although some of the “collusive” tactics described above may be illegal,

⁷See Office of Gas and Electricity Markets (1999), pages 173-4. In this market sellers bid supply schedules so “implicit collusion” leads to high prices.

A journalistic view is that “Far from being the success story trumpeted around the world, the story of the U.K. generation market and the development of competition has been something of a disaster. Despite decreasing levels of market concentration, as measured using the Hirschman/Herfindahl Index (HHI), and falling levels of input prices for generators, particularly coal, pool selling prices have failed to fall. The System Marginal Price (SMP) has actually risen in real terms since privatisation”, according to *Power U.K.*, issue 66, 31/8/99, p 14.

For academic analysis see von der Fehr and Harbord (1998), Newbery (1998), Wolfram (1998), and especially Wolfram (1999).

⁸[Note Z] This is analogous to a first-price sealed-bid auction.

⁹Whether this change is enough to fully resolve the problem in a market that has relatively few bidders and is so frequently repeated is beyond the scope of this paper. See Klemperer (2000).

¹⁰It is harder for bidders to collude if the repetition is finite, since collusion is no easier to sustain in the final auction than in a single auction, hence hard in the penultimate auction, etc.

or could be made illegal, it is much better to deal with these problems via auction design than by cumbersome rules that restrict bidders' flexibility, and may create inefficiencies, without being fully effective.

3. Entry Deterrence and Predation

Another key concern of competition policy is ensuring new entry is not too hard; an auction with too few bidders will both be unprofitable for the auctioneer¹¹ and potentially inefficient.

Ascending auctions may be particularly poor in this respect also. In an ascending auction there is a strong presumption that the firm which values winning the most will be the eventual winner because even if it is outbid at an early stage it can, and will, eventually top any opposition. So other firms have very little incentive to enter the bidding, and may not do so if they have any costs of bidding.

Consider, for example, Glaxo's 1995 takeover of the Wellcome drugs company (that created the world's largest drugs group). After Glaxo's first £9 billion bid, Wellcome solicited higher offers and received serious expressions of interest from two potential counterbidders: Zeneca was willing to offer about £10 billion if it could be sure of winning, while Roche considered an £11 billion offer.¹² The difficulty was that neither of the potential bidders wished to enter an auction that they expected to lose. The general perception was that there were particular synergies that made Wellcome worth a

¹¹In a notorious German auction of three radiospectrum licenses (in which no bidder was allowed to win more than one license) exactly three bidders entered. So no bidder needed to exceed the (modest) reserve price that had been set.

More generally, Bulow and Klemperer (1996) stress the value of attracting additional bidders, relative to other concerns in auction design.

¹²See *Financial Times* 8/3/95 p. 26, 27, 32, for this story and the direct quotes. (To be precise, the potential bidders are described as 'understood to be Zeneca', 'thought to be Roche', etc.)

little more to Glaxo than to any other potential bidder, and “Glaxo had let it be known that it would almost certainly top a rival bid”.¹³ Even though the costs of bidding were small compared with the stakes involved, they were non-trivial (tens of £ millions).¹⁴ So neither counterbidder actually entered the bidding; Wellcome was sold at the original £9 billion bid price, and its shareholders received literally billions of pounds less than they might have.¹⁵

This kind of problem will arise whenever the auction form makes one firm the likely winner.¹⁶ Potential opponents, who might sometimes have won, become no-shows. However, the problem is exacerbated, and can even drive out bidders with no costs of participating in the ascending auction, in “common-values” contexts in which bidders have the same (or close to the same) actual value but different information about that actual value.

The reason is the “winner’s curse”. When the prize has a similar value to everyone, every firm must bid cautiously to allow for the fact that it is most likely to win on those occasions when it has over-estimated the value of the prize. But beating an opponent with an advantage suggests one has over-estimated the value by even more, so one must bid even more cautiously. And if the weaker firms must be more cautious, the advantaged firm can be less cautious since beating very cautious opponents need not imply one has overestimated the prize’s value.¹⁷ So in an ascending auction a bidder

¹³*Financial Times* 8/3/95 p. 32.

¹⁴Glaxo’s own fees were reported to be £30 million net of stamp duty.

The point that even modest entry fees have a serious deterrence effect is analogous to the competition-policy point that the contestability of a market is non-robust to even small sunk costs.

¹⁵The chairman and chief executive of Wellcome stated afterwards “...there was money left on the table.” (*Financial Times* 8/3/95 p.32.) Note that for legal reasons Wellcome felt unable to pay other bidders’ costs of bidding, and might also have been precluded from other sales mechanisms (such as a sealed-bid auction). See Klemperer (1998).

¹⁶In auction-theorists’ language this is true in either “private-values” or “common-values” settings.

¹⁷That is, firms’ bids are very strongly “strategic substitutes” in the terminology of

with even a small advantage is justified in taking the view that it should almost always be prepared to outbid its rivals, if necessary, since its rivals will be being very cautious anyway. Therefore rational rivals will bid very cautiously, if they bother to bid at all, since they know they can beat the advantaged bidder only if the advantaged bidder has extremely discouraging private information about the value of the prize. And because weak rivals will bid cautiously, if at all, the advantaged bidder not only wins most of the time, but also generally pays a low price when it does win.

The bidding on the Los Angeles license in the main (1995, broadband) U.S. auction for mobile-phone licenses illustrates this problem. While the license's value was hard to estimate, it was probably worth very similar amounts to several bidders, except that Pacific Telephone had small but distinct advantages from its database on potential local customers, its well-known brand-name, and its executives' familiarity with California.¹⁸ The auction was an ascending auction.¹⁹ The result was that although some other firms did enter the auction and made some bids,²⁰ the bidding stopped at a price that most commentators thought was very low relative to the prices of other licenses where the auction was more symmetric.²¹

Bulow, Geanakoplos and Klemperer (1985). The point in this paragraph was first made by Bikhchandani (1988), and emphasised in these contexts by Klemperer (1998).

¹⁸Pacific Telephone was the "Baby Bell" which operated the wireline (fixed-line) telephone business in the area, and there might also have been other small economies of scope between the wireless and wireline businesses. Pacific Telephone also had no wireless properties prior to the auction, so had a strategic reason to enter the market as a hedge against its declining wireline business.

¹⁹More precisely, it was a simultaneous ascending auction, but this does not affect our argument.

²⁰Some potential bidders seem to have been scared out of the bidding altogether. For example, GTE and Bell Atlantic made deals that made them ineligible to bid for the Los Angeles license, and MCI—one of the US's largest phone companies—also failed to enter the auction at all.

²¹The price for the single Los Angeles license was \$26 per head of population. Compare this with Chicago where two licenses were sold for \$31 per head of population. Yet most commentators thought LA's demographics were superior to Chicago's (Southern

Because outcomes in an ascending auction can be dramatically influenced by apparently small advantages in valuation or in reputation for being a strong bidder, there is a strong incentive to invest in creating these advantages to deter the entry of potential rivals and to predate on actual rivals. Thus, for example, Glaxo made it very clear that it “would almost certainly top a rival bid”,²² and Pacific Telephone both said “if somebody takes California away from us, they’ll never make any money”²³ and also hired one of the world’s most prominent auction theorists to give seminars to the rest of the industry to explain the logic and implications of the “winner’s curse” argument that justifies this statement.²⁴

In another prominent example of apparent predation BSkyB (Rupert Murdoch’s satellite television company) last year attempted to acquire Manchester United (England’s most successful football club). The problem here was the potential effect on the auction of football TV rights. Since Manchester United receives 7 per cent of the Premier League’s television revenues, BSkyB would then have received 7 per cent of the price of the league’s broadcasting rights, whoever won those rights. So BSkyB would have had an

Californians are characterised as rich, loving new toys—as portable phones then were—and spending much of their time stuck on highways with little else to do than phone their friends), so that LA should have yielded the higher price.

A similar situation developed in New York and its license was also sold rather cheaply (\$17 per head of population).

For econometric evidence of the effects described here, in the FCC auctions more broadly, see Klemperer and Pagnozzi (2001). See also Bulow and Klemperer (2000).

²² *Financial Times* 8/3/95 p. 32.

²³ *Wall Street Journal* 31/10/94 p. A4.

²⁴ Note how anti-competitive the statements in this paragraph would seem in a normal competition-policy context in which dominant firms are threatened by new entry into their markets. The statement attributed to Glaxo would translate roughly to saying it “would almost certainly undercut any new entrant’s price”, while that attributed to Pacific Telephone would seem to correspond to threatening that “if anyone tries to compete with us, we’ll cut the price until they lose money.” Hiring an auction theorist to explain the winner’s curse to competitors might correspond to hiring an industrial economist to explain the theory of the difficulties entering new markets to potential entrants.

incentive to bid more aggressively in an ascending auction to push up the price of the rights and, knowing this, other potential bidders would have backed off. BSkyB might have effectively ended up with a lock over the TV rights with correspondingly deleterious effects on the pay TV (or even general TV) market more generally. Largely for this reason the U.K. Government blocked the acquisition.²⁵ Subsequently, however, and confirming this view of BSkyB's motive, BSkyB has taken smaller (mostly about 10 per cent) stakes in Manchester United, Manchester City, Chelsea, Leeds United and Sunderland thus obtaining a similar "toehold"²⁶ in the value of the league's television revenues while circumventing the competition watchdogs' restrictions on it owning too much of any one football club.²⁷ Meanwhile BSkyB's leading rivals have countered in similar style, with NTL, for example, taking partial stakes in Aston Villa, Leicester, Middlesborough, and Newcastle.²⁸

These are all examples of ascending auctions. Although an advantaged bidder is also more likely to win a sealed-bid auction, the outcome is much less certain because each bidder must make a single "best and final" offer in

²⁵[Note M] See U.K. Monopolies and Mergers Commission (1999). This report explicitly refers to Klemperer (1998) and Bulow, Huang and Klemperer (1999), etc., though none of these authors had any involvement in this case. The report also discusses difficulties with other auction forms in this context.

²⁶The effect described here was named the "toehold effect" by Bulow, Huang and Klemperer (1999) who first pointed out its importance in the context of takeover battles in which one or more contestants had "toeholds" in the target company. In this context there is empirical evidence that 'greater toeholds increase the probability of a successful single-bid contest by lowering both the chance of entry by a rival bidder and target management resistance' (Betton and Eckbo, 1995).

²⁷These stakes also gives BSkyB some rights over the clubs' internet broadcasting rights, which may increase the value of the main (live) rights to BSkyB, thus giving it a further advantage in the auction of the main rights.

²⁸And the Premier League responded by changing the format of its June 2000 TV rights auction to a sealed-bid style auction which resolved some of the difficulties (see below), but not all of them. In particular, not only did the rules include some ascending aspects, but it is also not clear that the League could or would in every circumstance have stuck to the result of the auction in the face of a further bid (or threats) from a defeated bidder, so this was not a pure sealed-bid auction. A pure sealed-bid auction may not be possible in this context. (See note M.)

the face of uncertainty about its rivals' bids. Since it is restricted to a single bid in a sealed-bid auction, the advantaged firm cannot follow the strategy it would use in an ascending auction of starting low and bidding higher only if it has to; because it wants to get a bargain, its sealed bid will not be the maximum it could be pushed to in an ascending auction. So “weaker” firms have at least some chance of victory in a sealed-bid auction. It follows that potential entrants are likely to be more willing to enter a sealed-bid auction than an ascending auction.²⁹ Furthermore, since a “weaker” bidder can win in less extreme circumstances in a sealed-bid auction, it also faces a less severe “winner’s curse”, and so is also likely to bid more strongly having entered the sealed-bid auction than it would bid in an ascending auction.³⁰

The logic is related to, but must be distinguished from, the standard competition-policy argument that a market that is in principle more competitive (for example, “Bertrand” rather than “Cournot”) is less attractive to entry, so may be less competitive in fact. The difference here is that a sealed-bid auction may both attract more firms than an ascending auction, *and* lead to more satisfactory outcomes for a given number of firms. So in our context there is no trade-off between competitiveness ex-post, and attracting entry ex-ante. Of course, just as the less competitive (Cournot) market sacrifices some ex-post production efficiency, a sealed-bid auction is less likely to allocate the prize to the party who values it most among a given set of bidders. But neither short-run production efficiency nor efficient allocation of the prize is the only objective. In particular, raising revenue should be an additional objective for a government, because of the substantial deadweight

²⁹These results all apply whether bidders have “private-values” or “common-values”.

³⁰This last result applies when there are some “common-values” components. For discussion of why the “winner’s curse” is much less significant in asymmetric sealed-bid auctions than in asymmetric ascending auctions see Klemperer (1998), Section 6.1.

losses of raising government funds through alternative methods.^{31,32}

4. Solving the Problems: the Anglo-Dutch Auction³³

So ascending auctions can often support both collusive and predatory activity. But an ascending auction is also particularly likely to allocate the prizes to the bidders who value them the most.^{34, 35} Furthermore, an ascending auction allows bidders to learn about others' valuations during the auction, which can both make the bidders more comfortable with their own assessments and often raises the auctioneer's revenues³⁶ if collusion and predation are absent.

So what should an auction designer do?

One solution to the dilemma of choosing between the ascending and sealed-bid forms is to combine the two in a hybrid, the "Anglo-Dutch",³⁷

³¹Feldstein (1999) estimates that for the U.S. "a marginal increase in tax revenue achieved by a proportional rise in all personal income tax rates involves a deadweight loss of two dollars per incremental dollar of revenue", although this is substantially higher than others' previous estimates.

³²Note that first-price sealed-bid and discriminatory auctions (which are in some ways analogous—see note Z) are not always more inviting to all kinds of new entry than are ascending and uniform-price auctions (which are analogous to each other—see note Y). For example, a bidder with inelastic demand for a small quantity can safely place a high bid in a uniform price auction in the knowledge that the price will be determined by others, but needs more information to make a sensible bid in a discriminatory price auction. Attractiveness to small bidders may not be important since they can buy from larger intermediaries who can aggregate smaller bidders' demands and bid in their places. However, our main, and robust, claim is just that attractiveness to entry is important. We do *not* claim that sealed-bid style auctions always dominate ascending style auctions in this respect.

³³The Anglo-Dutch auction was first described and proposed in Klemperer (1998).

³⁴At least among the bidders who show up. This is true even in many "common-values" settings. See Maskin (1992).

³⁵This is not necessarily the same as maximizing efficiency; when bidders are firms it ignores consumer welfare (which is likely to favour a more widely dispersed ownership than firms would choose) and, of course, it ignores government revenue.

Allowing resale is not normally a substitute for an efficient initial allocation. See Myerson and Satterthwaite (1983) and Cramton, Gibbons, and Klemperer (1987).

³⁶Milgrom and Weber (1982) show this is true if information is "affiliated".

³⁷Ascending and sealed-bid auctions are sometimes called English and Dutch auctions, respectively. Hence the name "Anglo-Dutch".

which often captures the best features of both.

For simplicity assume a single object is to be auctioned. Then in an Anglo-Dutch auction the auctioneer begins by running an ascending auction until just two bidders are willing to pay the current asking price. That is, the price is raised continuously until all but two bidders have dropped out. The two remaining bidders are then each required to make a “best and final” sealed-bid offer that is not lower than the current asking price, and the winner pays his bid. The process is much like the way houses are often sold, although unlike in many house sales the procedure the auctioneer will follow in an Anglo-Dutch auction is clearly specified in advance.

The main value of this procedure is when one bidder (for example, the incumbent operator of a license that is to be re-auctioned) is thought to be stronger than potential rivals. Absent the final sealed-bid, the potential rivals might be unwilling to enter against the strong bidder who would be perceived to be a sure winner. But the sealed-bid induces some uncertainty about which of the two finalists will win, and entrants are attracted by the knowledge that they have a chance to make it to this final stage. So the price may easily be higher even by the end of the first, ascending, stage of the Anglo-Dutch auction, than if a pure ascending auction were used. At the same time the Anglo-Dutch procedure will generally be more likely to sell to the highest valuer than a pure sealed-bid auction, both because it directly reduces the numbers allowed into the sealed-bid stage and also because the two finalists can learn something about each other’s and the remaining bidders’ perceptions of the object’s value from behaviour during the ascending stage.

The Anglo-Dutch auction can be extended to multi-object contexts, including contexts in which individual bidders are permitted to win multiple units. In these cases it has the additional advantage of making collusion much harder than in a pure ascending auction;³⁸ because the sealed-bid stage allows firms to renege on any tacit deals without fear of retaliation, they are unlikely to make such deals in the first place.^{39, 40}

Analysis of other factors suggests that the Anglo-Dutch may have additional merits. In particular, the ascending stage of the Anglo-Dutch auction may extract most of the information that would be revealed by a pure ascending auction, and hence capture most of the consequent benefits of raising revenues⁴¹ and making bidders more comfortable with their own assessments. At the same time the Anglo-Dutch may do almost as well as a pure sealed-bid auction in capturing extra revenue (relative to what would be expected from an ascending auction) due to the effects of bidders' risk-aversion, budget-constraints, and asymmetries. These effects apply even if the Anglo-Dutch auction attracts no more bidders into the market.⁴²

In short, the Anglo-Dutch auction often combines the best of both the ascending and the sealed-bid worlds.⁴³

³⁸In the single-indivisible-object case, tacit collusion is unlikely to be a problem since bidders cannot share the spoils without resort to side-payments.

³⁹Furthermore, if there are complementarities between the objects, the ascending stage makes it more likely that bidders will win efficient bundles than in a pure sealed-bid auction in which they can learn nothing about their opponents' intentions.

⁴⁰Obviously the auction designer's armoury has many other tools that fight collusion and predation, for example, reserve prices (possibly secret), policies about what information is released, etc.

⁴¹Milgrom and Weber (1982) shows the information revealed raises expected revenues if bidders' information is "affiliated".

⁴² However, the effects in this paragraph are conjectures that need further research to confirm.

⁴³Many variants of the Anglo-Dutch auction are possible. With a single object for sale it may be desirable to move to the sealed-bid stage when there are still more than two bidders remaining. With multiple homogenous objects there is a choice between a

5. The U.K. and Netherlands Mobile-Phone License Auctions⁴⁴

The U.K. (March-April 2000) and Netherlands (July 2000) third-generation mobile spectrum license auctions illustrate how good auction design is sensitive to the context:

The U.K. originally planned to auction just *four* third-generation licenses. In this case the presence of exactly four incumbent operators who might be thought to have advantages over other bidders⁴⁵ meant the designers were very concerned that an ascending auction might deter new firms from bidding strongly in the auction, or even from entering the auction at all.⁴⁶ So in this case the government proposed running an Anglo-Dutch auction. An ascending auction would have continued until just five bidders remained, after which the five survivors would have made sealed-bids (required to be no lower than the current price level) for the four licenses.⁴⁷ The design

discriminatory and a uniform price (but using the lowest-winner's price *not* the highest runner-up's price) sealed-bid stage. With N objects the ascending stage will typically continue until $N+1$ bidders remain, but the rule for moving to the sealed-bid stage is more complex if bidders are allowed to win multiple objects. If objects are heterogeneous, the ascending stage for each object should probably be completed simultaneously and independently, as in a Simultaneous Ascending auction, prior to collecting the sealed bids for any object, and a rule for ordering the sealed bids for the different objects is required.

⁴⁴I was the principal auction theorist advising the Radicommunications Agency which designed and ran the U.K. auction. Ken Binmore had a leading role and supervised experiments testing the proposed designs. Other academic advisors included Tilman Borgers, Jeremy Bulow, Philippe Jehiel, and Joe Swierzbinski. *The views expressed are mine alone.*

⁴⁵BT, One2One, Orange and Vodafone were the existing operators and were probably generally predicted to be the "strong" bidders, both because of their brand-name advantages over a new entrant, and because of their lower costs of building out a network.

⁴⁶[Note N] Efficiency was the main concern of the U.K. government. More precisely, in a written answer to a Parliamentary Question, Barbara Roche, then Minister for Small Firms, Trade and Industry, said "In offering through an auction licences to use specified frequencies for the delivery of UMTS, the Government's overall aim is to secure, for the long term benefit of UK consumers and the national economy, the timely and economically advantageous development and sustained provision of UMTS services in the UK.

Subject to this overall aim the Government's objectives are to (i) utilise the available UMTS spectrum with optimum efficiency; (ii) promote effective and sustainable competition for the provision of UMTS services; and (iii) subject to the above objectives, design an auction which is best judged to realise the full economic value to consumers, industry and the taxpayer of the spectrum." See *Hansard*, 18 May 1998.

⁴⁷In this case it was proposed that all four winners would pay the fourth-highest sealed

performed extremely well in laboratory experiments commissioned by the Radiocommunications Agency.⁴⁸

However, when it became possible to auction *five* licences, a straightforward ascending auction was no longer counterindicated, even though there were non-trivial entry costs and relatively few potential bidders.⁴⁹ Because no bidder was permitted to win more than one license and licenses could not be divided, every bidder would end up either a winner of a single license, or a loser. So bidders could not collude to divide the market because there was no way to share the spoils without resort to sidepayments. Furthermore, with five licenses and only four incumbents, at least one license had to go to a new entrant and this would be a sufficient carrot to attract several new entrants.⁵⁰ So the problems of collusion and entry deterrence that this paper has emphasised were minimal in the U.K. context, and other considerations

bid, and a final Simultaneous Ascending stage would have followed to allocate the four licenses more efficiently among the four winners. See Radiocommunications Agency (1998a, b) for more details.

⁴⁸It performed well both in terms of efficiency (which was the main concern of the U.K. Government—see note N) and revenue generation (which was only a tertiary objective—see note N). The Anglo-Dutch design was also very successful in [confidential information censored while publication permission sought].

⁴⁹Of course, predation and collusion are likely to be very hard when a commodity such as gold is offered to a potentially large number of bidders for whom entry to the auction is easy. In this case auction-design issues are likely to be of second-order importance to either price or efficiency. (Since I have been asked to serve on a National Audit Office Panel of Experts to review the sale of the U.K.'s gold stock-pile, it must be stressed that this view about gold is purely personal. And of course running an auction may be very important for transparency, and what is announced about the government's policies is certainly important to the market.)

Similarly, though much ink has been spilt on the subject, auction design may also not be critical for many government-security sales, (although collusion has arisen in some of these). For example, the U.S. Treasury's recent experiments with using uniform price auctions in place of discriminatory auctions yielded inconclusive results. See, for example, Simon (1994), Malvey, Archibald and Flynn (1996), Nyborg and Sundaresan (1996), Reinhart and Belzer (1996), and Ausubel and Cramton (1998). The broader empirical literature is also inconclusive. See Klemperer (2000b) for more discussion.

⁵⁰Note that the simultaneous ascending design also guarantees that there are entrants available to threaten *every* incumbent until all the objects are finally allocated simultaneously.

militated towards an ascending design.⁵¹

Therefore a version of an ascending auction was actually used, and it was widely judged to be a success; there were nine new entrants who bid strongly against the incumbents, creating intense competition and record-breaking (\$34 billion) revenues.

However, given the importance of the relationship between the number of incumbents and the number of licenses, the Netherlands plan to follow the actual British design was ill-conceived since there were *five* incumbent operators and *five* licenses in the Netherlands. It was not hard to predict (indeed the first draft of this paper, written two months prior to the auction *did* predict) that very few entrants would show up. Recognizing their weak positions, the potential new entrants made deals with incumbent operators, and Netherlands competition policy was as dysfunctional as the auction design, allowing firms such as Deutsche Telekom, DoCoMo and Hutchinson, who were all strong established players in other markets than the Netherlands, to partner with the local incumbents.⁵² In the end there was just one relatively weak entrant (Versatel) to compete with the five incumbents for the five licenses. Not surprisingly, the auction finally raised less than one

⁵¹In particular, the five licenses were of unequal sizes. A sealed-bid component to the design might have introduced some inefficiency in the allocation of licenses among winners.

The ascending design chosen was a version of the one which was originally sketched by Vickrey (1976), and proposed and developed by McAfee, Milgrom and Wilson for the U.S. auctions. When each of an exogenously fixed number of bidders has a privately-known value for each of a collection of heterogenous objects, and (as in the U.K., but contrary to the U.S.) is restricted to buying at most a single license, the unique Nash equilibrium of the game induced by this design is efficient if bidding increments are arbitrarily small. (For more discussion of the U.S. sales see McMillan (1994), McAfee and McMillan (1996) and especially Milgrom (forthcoming).)

⁵²It would normally be better if combinations between potential entrants and incumbents had to wait until after the auction, just as the sale of Orange to France Telecom waited until after the U.K.'s auction. Similarly, the sale of part of Hutchinson's interest in its U.K. license after the auction to KPN and DoCoMo did not harm the British taxpayer, but allowing these firms to combine before the Netherlands auction hurt taxpayers there.

third of the per-capita revenue of the U.K. auction, that is, only \$2.5 billion, rather than the almost \$8.5 billion the Dutch government had forecast based on the U.K. experience.

6. Market Structure and the German Mobile-Phone License Auction

In addition to addressing problems of *conduct*, especially collusion and predation, competition authorities also analyse the merits of mergers and other changes to market *structure*.

Our paper has focused attention on conduct, taking structure as given. In many auctions, such as those of oil, gold, financial instruments, etc., there is no issue about market structure. But when creating a new industry, its structure is crucial. For example, when auctioning radiospectrum for third generation mobile-phone services, auction designers must consider the competitiveness of the mobile-phone market that will be created by the auction.⁵³ Simply “letting the market decide” will bias the auction’s result towards too few winners each of whom will win too much spectrum, since outcomes are driven by bidders’ profits, not by final-consumers’ surplus, and bidders’ joint profits are maximised by a monopoly over radiospectrum.⁵⁴

This is the critical defect of the planned German mobile-phone license auction in which the number of winners is endogenous. Germany plans to auction twelve blocks of spectrum from which bidders can create “licenses” of either two or three blocks (e.g. four firms could win large 3-block licenses

⁵³Similarly, the most important issues for the competition authorities in regulating the sale of football TV rights are: What packages are sold?, and How many packages is a single broadcaster allowed to win?

⁵⁴Though the “demand-reduction” effect emphasised by Ausubel and Cramton (1998) mitigates the bias.

or six firms could win smaller 2-block licenses), so the German government has risked obtaining an overly concentrated mobile-phone market.⁵⁵

7. Conclusion

Auction design is a matter of “horses for courses”, *not* “one size fits all”. While the ascending auction is very risky in many contexts, it has also been used very successfully in other contexts, including the recent U.K. and some U.S. radiospectrum auctions.

The recent U.K. and Netherlands examples show that auction design is very sensitive to the details of the environment. European governments would be foolish not to copy the U.K. in auctioning the radiospectrum, but they would be equally foolish to blindly follow the exact U.K. design without attention to their local circumstances.

In auction design, the devil is in the details.

⁵⁵See Jehiel and Moldovanu (2000a) and the references therein for more discussion of the German auction, and Jehiel and Moldovanu (2000b) for some more general analysis of license auctions and market structure.

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