WHAT REALLY MATTERS
IN
AUCTION DESIGN

REVISED AND EXTENDED VERSION

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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, and the Anglo-Dutch auction—a hybrid of the sealed-bid and ascending auctions—may often perform better. Effective anti-trust policy is also critical.

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, but this author (and others) correctly predicted the same format would fail in the Netherlands and elsewhere. Auction design is **not** "one size fits all".

We also discuss the 3G spectrum auctions in Germany, Italy, Austria and Switzerland, and football TV-rights, TV franchise and other radiospectrum auctions, electricity markets, and takeover battles.[1]

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1 Introduction

Auctions have became enormously popular in recent years. Governments are now especially keen, substituting auctions for administrative procedures to allocate assets such as mobile-phone licenses; using auctions to operate new markets such as the electricity pools through which competing generators now supply power in many countries; auctioning privatised companies, etc. And the growth of e-commerce has encouraged businesses to organise auctions for many inputs and outputs whose trade was previously negotiated bilaterally.

Economists are proud of their role in pushing for auctions; for example, Coase (1959) was among the first to advocate auctioning radiospectrum. But in spite of all the enthusiasm, many auctions—including some designed with the help of leading academic economists—have worked very badly indeed. For example, Table 1 shows the price per capita raised for the very similar blocks of spectrum sold for third-generation mobile-phone services in six European countries in April-December 2000, which cumulatively raised around \$100 billion or over $1\frac{1}{2}\%$ of the countries' combined GDP.

INSERT TABLE 1 HERE

Table 1 makes clear that running an auction is not enough for success. The design details must also be correct.

So what makes a successful auction?

There is now an extensive auction literature (summarized in, e.g., Klemperer (1999a, 2000a)) that has also made significant contributions in many economic contexts not ordinarily thought of as auctions[1] (see Klemperer, 2001). But most of this literature is of second-order importance for practical auction design.

What really matters in designing auctions are the same issues that any industry regulator would recognise as his key concerns: discouraging collusive, entry-deterring and predatory behaviour.

In short, good auction design is mostly good elementary economics.

Section 2 lists—and gives examples of—some critical pitfalls in auction design. We show that ascending auction and uniform-price auctions are both particularly vulnerable to collusion (Section 2A), and particularly likely to deter entry into an auction (Section 2B). We discuss other problems (Section 2C), and also contexts in which the auction form may not be critical (Section 2D).

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[1] For example, financial crashes, political contests and lobbying, litigation systems, queues and rationing, wars of attrition, and price-setting oligopolies.

Section 3 discusses what to do about these problems. We consider including a final "sealed-bid" stage into an otherwise-ascending auction to create an "Anglo-Dutch" auction (Section 3A), and emphasize the need for stronger anti-trust policy in auction markets (Section 3B).

Section 4 looks at the European third-generation mobile-phone license auctions in more detail as a case study.

Section 5 considers the role of auction design in determining market structure, and we conclude in Section 6.

2. Pitfalls

A. Facilitating Collusion

Multi-unit ascending and uniform-price auctions are more vulnerable than first-price and discriminatory auctions to collusion, especially "tacit" collusion.[2] While explicit collusion can be a problem, tacit coordination among firms is often a bigger concern, just as this is probably the greater problem for competition policy given existing law.

We discuss some of the different ways in which ascending and uniform-price auctions facilitate collusion, giving an example of each.

(i) Ascending Auctions Allow Signalling to "Divide the Pie"

A key issue for firms attempting to collude is agreeing how to share the spoils. 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, consider the 1999 German sale of ten blocks of spectrum by a simultaneous ascending auction with the rule that any new bid on a block had to exceed the previous high

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[2][Note E] An ascending auction is the standard auction used, for example, to sell a painting in Sotheby's or Christies: the price starts low and competing bidders raise the price until no-one is prepared to bid any higher, and the final bidder then wins the painting at the final price he bid; in a multi-unit (simultaneous) ascending auction, several objects are sold at the same time, with the price rising on each of them independently, and none of the objects is finally sold until no-one wishes to bid again on any of the objects.

In a first-price (or first-price sealed-bid) auction for an object, each bidder simultaneously makes a single best-and-final sealed bid, and the bidder who makes the highest bid receives the object and pays the price he bid.

Discriminatory (or pay-your-bid) and uniform-price auctions are often used when selling many identical objects, for example, units of electricity or treasury bonds. In each case, each bidder simultaneously submits a demand curve specifying how many units the bidder offers to buy at each possible price. The auctioneer then determines the price at which the total demand equals the supply he has available, and allocates each bidder the quantity that he demanded at this clearing price. In a uniform-price auction every bidder simply pays the clearing price for every unit he is allocated. In a discriminatory (or pay-your-bid) auction each bidder pays the most for each unit that he was willing to pay according to his demand curve.

bid by at least 10%. Mannesman's first bids were 18.18 million DM per MHz on blocks 1-5 and 20 million DM per MHz on blocks 6-10. These were low prices, but the only other credible bidder—T-Mobil—bid even less in the first round. Here is what one of T-Mobil's managers then said. "There were no agreements with Mannesman. But Mannesman's first bid was a clear offer." The point, of course, is that 18.18 plus a 10% raise equals $19.998 \approx 20$. It seems T-Mobil understood that if it bid 20 million DM per MHz on blocks 1-5, but did not bid again on blocks 6-10, the two companies would then "live and let live" with neither company challenging the other on "the other's" half. Exactly that happened. So the auction closed after just two rounds with each of the bidders acquiring half the blocks for the same low price (see Frankfurter Allgemeine Zeitung, 29/10/99, p.13, and Jehiel and Moldovanu (2000).)

By contrast, bidders cannot easily achieve the same coordination in simultaneous sealed-bid auctions, in which each player simultaneously makes a single "best and final" offer for each object, so players would be unable to respond to others' signals.

(ii) Ascending Auctions Allow Punishment of Rivals to Support Collusion

In order to collude, firms must be able to punish rivals who fail to co-operate. The threat of punishment may be implicit—it was clear to T-Mobil that Mannesman would retaliate with high bids on blocks 1-5 if T-Mobil continued bidding on blocks 6-10—but an ascending auction can also allow a firm to make the point more explicitly.

Consider, for example, the multi-license 1996-97 U.S. spectrum auction in which U.S. West was competing vigorously with McLeod for a license in Rochester, MN, while McLeod seemed to be the uncontested high-bidder for licenses in Waterloo, IA and Marshaltown, IA. Rochester's lot-number was 378, and although most bids in the auction had been in exact $1000s, U.S. West bid $313,378 in Waterloo and $62,378 in Marshaltown, and made other similar bids apparently intended to punish McLeod. McLeod got the point and stopped competing in Rochester. Since McLeod, as U.S. West presumably intended, did make subsequent higher bids in Waterloo, Marshaltown, etc., U.S. West's "punishment" bids were costless to U.S. West. (See Cramton and Schwartz (1999), and "Learning to Play the Game", The Economist, 17/5/97, p.120.)

Again, of course, a sealed-bid auction would not give the firms any opportunity to retaliate against a bidder who fails to cooperate.

(iii) Uniform-Price Auctions Allow "Extra" Bids to be used as a Punishment Device

In the previous example, firms made bids that were never intended to actually win, in order to punish their rivals. A closely related phenomenon can arise in one special kind of sealed-bid auction, namely a uniform-price auction in which bidders bid demand functions for multiple units of a homogenous good (e.g. electricity). In a uniform-price auction the price for every

unit is set only by the lowest winning bid,[3] 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. That is, bidders can tacitly agree to divide up the market at a very favourable price for themselves by each bidding extremely aggressively for smaller quantities than "its collusive share", thus deterring other bidders from bidding for more.[4],[5]

The U.K. electricity regulator believes this market has fallen prey to exactly this kind of "implicit collusion" (Office of Gas and Electricity Markets (1999), pages 173-4). "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." (Power U.K., issue 66, 31/8/99, p 14. See also von der Fehr and Harbord (1998), Newbery (1998), Wolfram (1998, 1999).)

By contrast, "implicit collusion" is harder in a discriminatory auction in which every winner pays its actual bids for the quantity it wins,[6] 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—although this may not fully resolve the problems since the market has so few bidders and is so frequently repeated, and it may also create other problems (see Section 2B (vi), Klemperer (1999b)).

(iv) Ascending Auctions Encourage Violation of the Rules to Collude

Much, perhaps all, of the kind of behaviour discussed above is hard to challenge legally. (And trying to outlaw it all would require cumbersome rules that restrict bidders' flexibility and might generate inefficiencies, without being fully effective.) But behaviour that is clearly illegal is also a concern.

The ease of punishing rivals who defect from a collusive agreement within ascending and uniform-price auctions means that these auction forms are more susceptible to illegal cartel

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[3]See note E for the details of this auction form.

[4][Note Y] Since with many units, the lowest winning bid in a uniform-price auction is typically not importantly different from the highest losing bid, 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 the implicit threats supporting collusion in an ascending auction.

[5]Note that this "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). The "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).

[6][Note Z] This is analogous to a first-price sealed-bid auction. See note E for the details.

formation than are conventional first-price sealed bid auctions and discriminatory auctions.[7], [8]

Rule violation can be a particular problem when just one bidder needs to be eliminated to end an auction, since it may not be credible for the auctioneer to punish an offending bidder.

Consider, for example, the August 2000 German 3G spectrum auction. This was an ascending auction and, when it could have ended after just one more bidder quit,[9] MobilCom told a newspaper that it "would welcome customers from...Debitel should [Debitel] fail to secure a license [so Debitel could] become a 'virtual network operator' using MobilCom's network while saving on the cost of the license." (Financial Times, 2/8/2000 p.28.) If taken literally, this would be similar to the offer of a side-payment for quitting the auction. However, the government did not attempt to punish MobilCom, perhaps because excluding it would have risked ending the auction almost immediately at an extremely low price (about 3% of what the auction finally achieved[10]), and because it might be hard for the government to impose fines large enough to have a serious deterrent effect (literally billions of euros would be required in this context). Shares in Debitel rose 12 per cent in response to MobilCom's remarks, and although it did not quit immediately it did drop out at a relatively low price. In the end, the German auction had a happy ending for the government—see Section 4E—but this was good luck, not good design.

Of course any auction is more vulnerable to collusion when just one bidder needs to withdraw to end the auction, but only an ascending auction necessarily passes through a stage where there is just one excess bidder.

(v) Inadequate Reserve Prices Encourage Collusion

Inadequate reserve prices increase the potential gains from joint-bidding or colluding, and encourage tacit collusion that would not otherwise have been in all bidders' interests. A

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[7]In a first-price sealed bid auction each object is sold to the highest bidder at the price it bid for that object. In a second-price sealed-bid auction the winner pays the runner-up's price. This makes a cartel easier to sustain, since if the cartel agrees to a high winning bid but a low runner-up bid the price will be low, but (unlike in a first-price auction) losers gain nothing by raising their bid a little above this winning price. This is analogous to the problem with the uniform price auction discussed in the previous section (2A (iii)). The second-price and uniform-price auctions are more generally analogous to ascending auctions (in which every winner pays the runner-up's willingness to pay). See note Y.

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

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).

[9]Bidders were allowed to win two or three each of the twelve available lots, so the number of winners had to be four, five, or six. The event described took place when seven bidders were present.

[10]The reserve price was absurdly low.

stronger bidder in an ascending auction has a choice between either tacitly colluding to end the auction quickly at a low price, or forcing the price up to drive out weaker bidders; the lower the reserve price at which the auction can be concluded, the more attractive is the first option.

Consider, for example, the November 2000 Austrian 3G spectrum auction in which just six firms competed for twelve identical lots in an ascending auction and in which a firm was required to win at least two lots to receive a license. Because the government had set a very low reserve price—just one-eighth of the per capita price that the identical German 3G auction had achieved three months earlier—the incentive for the six firms to tacitly agree to divide up the market so each firm won two lots was very great.[11] Any bidder who might have been inclined to compete for a third unit knew he would have to drive the price up a very long way to drive out another bidder (and he would then have to pay this high price on all three units). So the bidding stopped very soon after starting at the reserve price. It is rumoured that the bidding only lasted the few rounds it did in order to create some public perception of genuine competition and reduce the risk of the government changing the rules; the final price was less than one-sixth of the per capita revenue raised in the U.K. and Germany.

Other aspects of the Austrian design can be criticised (Sections 4E, 4F). But just fixing the reserve price would have given a chance of revenues closer to German levels.

B. Entry Deterrence and Predation

The second major concern of auction design is to attract bidders to the auction, as an auction with too few bidders will be both unprofitable for the auctioneer, and potentially inefficient.[12] We show ascending auctions are often particularly poor in this respect, since they can allow some bidders to deter the entry, or depress the bidding, of rivals.

(i) Ascending Auctions Deter Bidders with (Even Small) Disadvantages

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 at all if they have any costs of bidding.[13]

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[11]The agreement may not have been completely tacit. The largest incumbent, Telekom Austria was reported the week before the auction as saying it "would be satisfied with just two of the 12 blocks of frequency on offer and if the others behaved similarly, 'it should be possible to get the frequencies on sensible terms'...but that it would bid for a third frequency block if one of its rivals did." (Reuters 31/10/00 Austrian UMTS Auction Unlikely to Scale Peaks.)

[12]Bulow and Klemperer (1996) stress the value of attracting additional bidders, relative to other concerns in auction design. For a theoretical application of this point see Gilbert and Klemperer (2000).

[13]This point that even modest entry fees may be a serious deterrent is analogous to the competition-policy point that the contestability of a market is non-robust to even small sunk costs.

Consider, for example, Glaxo's 1995 takeover of the Wellcome drugs company (that created the world's then-largest drugs group). After Glaxo's first $9 billion bid, Zeneca expressed willingness to offer about $10 billion if it could be sure of winning, while Roche considered an $11 billion offer. But there were particular synergies that made Wellcome worth a little more to Glaxo than to the other firms, neither of whom wished to enter an auction that they expected to lose. Even though the costs of bidding were small compared with the stakes involved, they were non-trivial (tens of $ millions—Glaxo's own fees were around $30 million). So neither Roche nor Zeneca actually entered the bidding, and Wellcome was sold at the original $9 billion bid price, literally billions of pounds less than its shareholders might have received.[14]

A (first-price) "sealed-bid" auction might have fared far better. Although an advantaged bidder will probably win a sealed-bid auction, the outcome is much less certain than in an ascending auction because each bidder must make a single "best and final" offer in 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.[15],[16]

(ii) The "Winner's Curse" Depresses Bidding in Ascending Auctions

When bidders have the same, or close to the same, actual value for a prize, but they have different information about that actual value (what auction theorists call the "common values" case), each bidder must bid cautiously to allow for the "winner's curse", that is, 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 advantaged opponent suggests one has overestimated the value by even more, so weaker firms must bid even more cautiously. And therefore an advantaged firm can be less cautious, since beating very cautious opponents need not imply one has overestimated the prize's value.[17] In fact, in an ascending auction the advantaged player can always correctly

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[14]Wellcome's own chief executive admitted "...there was money left on the table." See Financial Times 8/3/95 p. 26, 27, 32. To be precise, the potential bidders are described as 'understood to be Zeneca', 'thought to be Roche', etc.

[15]Vickrey (1961) Appendix III offers a simple example in which a bidder who would surely lose an ascending auction would make expected positive profit in a first-price sealed-bid auction.

Legal reasons might have precluded Wellcome from using a sealed-bid auction, and from other strategies such as paying other bidders' costs of bidding (See also Section 2C (iii) and Klemperer, 1998).

[16][Note R] If resale is permitted, a sealed-bid auction might encourage bidders who enter only in order to resell. By contrast, permitting resale will have less impact on an ascending auction, since it is difficult for bidders to profit from reselling to bidders they have beaten in an ascending auction.

[17]That is, firms' bids are very strongly "strategic substitutes" in the terminology of Bulow, Geanakoplos and Klemperer (1985a,b). This point was first made by Bikhchandani (1988), and emphasised in these contexts by Klemperer (1998).

argue that "if my opponent is prepared to bid up to \$X, I should be prepared to bid a little further, since we all know the prize is worth more to me". So the advantaged bidder not only wins most of the time but—because its rivals bid very cautiously—also generally pays a low price when it does win.

The bidding on the Los Angeles license in the main (1995, broadband) U.S. FCC 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. But Pacific Telephone (the "Baby Bell" which operated the local wireline (fixed-line) telephone business) had small but distinct advantages from its database on potential local customers, its well-known brand-name, its executives' familiarity with California, etc. The auction was an ascending auction. The result was that the bidding stopped at a very low price. The Los Angeles license yielded \$26 per capita, while Chicago's more symmetric auction yielded \$31 per capita even though Chicago's demographics were inferior.[18] For formal econometric evidence for the FCC auctions more broadly, see Klemperer and Pagnozzi (2001).

Of course, the "winner's curse" problem exacerbates the problem that even slightly weaker bidders may not bother to participate in an ascending auction. In fact, some potential bidders do seem to have been completely scared out of the bidding for the Los Angeles license; GTE and Bell Atlantic made deals that made them ineligible to bid, and MCI failed to enter the FCC auction at all.

In a sealed-bid auction, the "winner's curse" problem for a weaker bidder is far less severe. Winning an ascending auction means the weaker bidder is paying a price his rival is unwilling to match—which should make him very nervous. But the weaker player has a chance of winning a sealed-bid auction at a price his rival would be willing to match, because the rival gets only one bid, and won't bid the maximum it would be willing to pay because it wants to make a profit when it wins. Since beating the stronger player isn't necessarily bad news in a sealed-bid auction, the weaker player can bid more aggressively. So auction prices will be higher, even for a given number of bidders (Klemperer (1998), Bulow, Huang and Klemperer (1999)).[19], [20]

(iii) Ascending Auctions Encourage Predatory Behaviour

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[18]Commentators characterized Southern Californians 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!

[19]In Milgrom and Weber's (1982) model sealed-bid auctions are less profitable than ascending auctions if signals are "affiliated". But they assume symmetric bidders, and the effect does not seem large in practice (Riley and Li (1997)).

[20]The logic is related to the standard competition-policy argument that a market that is in principle more competitive (for example, "Bertrand" rather than "Cournot") is less attractive to enter, so may in fact be less competitive. The difference here is that a sealed-bid auction may both attract more firms than an ascending auction, and lead to better outcomes for the auctioneer for a given number of firms.

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.

Thus, for example, Glaxo made it very clear that it "would almost certainly top a rival bid" (Financial Times 8/3/95 p.32), while Pacific Telephone said "if somebody takes California away from us, they'll never make any money" (Wall Street Journal 31/10/94 p. A4). Pacific Telephone 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. And it divested itself of other wireless properties and made internal organisational changes that increased its commitment to winning the Los Angeles license.

In another prominent example of apparent predation, BSkyB (Rupert Murdoch's satellite television company) in 1999 attempted to acquire Manchester United (England's most successful soccer club). The problem 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 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.[21], [22]

(iv) Auctions with Few Bidders are Vulnerable to Predatory Rule-Violations

As with rules against collusion, enforcing rules against predation may be problematic when just one bidder needs to be eliminated to end an auction.

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[21]The problem described was coined the "toehold effect" by Bulow, Huang and Klemperer (1999) in the context of takeover battles: Takeover battles are essentially ascending auctions and there is empirical evidence that having a larger shareholding "or toehold" in the target company "increase[s a bidder's] 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).

The term "toehold effect" entered the popular press and the U.K. Monopolies and Mergers Commission (1999) report which effectively decided the case. 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.

[22]Subsequently, and supporting 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" 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. But BSkyB's leading rivals have countered in similar style, with NTL, for example, taking partial stakes in Aston Villa, Leicester, Middlesborough, and Newcastle. And the Premier League responded by changing the format of its June 2000 TV rights auction to a "best and final" sealed-bid style auction which resolved some of the difficulties (see below), but not all of them. See Section 2C (iii).

For example, in the July 2000 Netherlands 3G spectrum auction, six bidders competed for five licenses and bidders were permitted to win just one license each, so the auction would end as soon as one bidder quit. One bidder (Telfort) sent a letter to another (Versatel) threatening legal action for damages if Versatel continued to bid! Telfort claimed that Versatel "believes that its bids will always be surpassed by [others'...so it] must be that Versatel is attempting to either raise its competitors' costs or to get access to their...networks". Although Versatel complained to the government, the government took no action at all—not even holding an investigation—perhaps because excluding Telfort would have ended the auction immediately "cutting off the government's nose to spite its face", and it might have been hard to impose a meaningful fine. Versatel then quit the auction, apparently in response to the letter and the government's inaction, so the auction raised less than 30% of what the Dutch government had forecast based on the U.K.'s result—see below.[23]

Of course, any auction could suffer this kind of predation, but an ascending auction is especially vulnerable. Even if the auction does not start with few bidders, the predation can take place when only few remain, and the ascending structure allows the predator time to assess the success of its strategy.

(v) Deterring Weaker Bidders Encourages Joint Bidding and Collusion

Because an ascending auction often effectively blocks the entry of "weaker" bidders, it encourages "stronger" bidders to bid jointly or to collude—they know that no one else can enter the auction to steal the collusive rents they create.

For example, the November 2000 Swiss 3G spectrum auction was an ascending auction for four licenses in which bidders were allowed to win at most one each. There was considerable initial interest from potential bidders. But weaker bidders were put off by the auction form—at least one company hired bidding consultants and then gave up after learning that the ascending-bidding rules would give the company very little chance against stronger rivals. And the government permitted last-minute joint-bidding agreements—essentially officially-sanctioned collusion—so the field shrank from nine bidders to just four (!) in the week before the auction was due to begin. The only reason the auction yielded more than the reserve price was that slight differences between the licenses led to a very little competition for the best license, and a final average price just $2\frac{1}{2}\%$ higher. Unfortunately the reserve price had been set absurdly low (which further increased the incentive for joint-bidding, see Section 2A (v)), so the Swiss received just one-thirtieth of the U.K. and German per capita revenues, and one-fiftieth of what they had once hoped for!

By contrast, in a sealed-bid auction, if the strong firms form a consortium they may simply attract other firms into the bidding in the hope of beating the consortium. For example,

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[23]Six months later the Dutch parliament began an investigation into the entire auction process.

Deutsche Telekom or Hutchinson who had both won licenses in Germany, Austria, Netherlands, U.K., and elsewhere, and who had quit the Swiss auction just one week earlier, might perhaps have re-entered a sealed-bid contest. So the strong firms are more likely to choose to bid independently in a sealed-bid auction, making this a much more competitive auction.

(vi) Discriminatory Auctions Deter Bidders with Limited Information

We have emphasised problems of ascending and uniform-price auctions. But they are not always less inviting to entry than first-price sealed bid or discriminatory auctions. A disadvantage of the latter auctions is that, because winners pay their own bids, bidders need to have good information about the distribution of their rivals' costs in order to bid intelligently. So bidders with smaller demands, for whom the costs of obtaining market information are not worth paying, may be deterred from entering these auctions.

This issue may not be important if such bidders can buy from larger intermediaries who can aggregate smaller bidders' demands and bid in their places as, for example, in treasury auctions.[24] However the U.K.'s New Electricity Trading Arrangements (see Section 2 A (iii)) might discourage new entrants into this industry if satisfactory intermediaries or a transparent exchange market do not develop (Klemperer (1999b)).

By contrast, a bidder who only has good information about his own value may prefer an ascending or uniform-price auction in which the best strategy is just to bid (up to) his own value and winners' payments are determined by non-winners' bids.[25]

(vii) Inadequate Reserve Prices Exacerbate Entry Problems

Sometimes, whether because of poor auction design or the nature of the object(s) for sale, there turns out to be no effective competition.[26] In this case a serious reserve price is critical.

The 1991 U.K. auction of TV franchises by a first-price sealed-bid auction is a dramatic example. While the South and South East, South West, East, Wales and West, North East and Yorkshire all sold in the range $9.36 to $15.88 per head of population, the only—and therefore winning—bid for the Midlands region was just one-twentieth of one penny (!) per head of population. The Midlands region's demographics were certainly not inferior, but bidders were required to provide very detailed region-specific programming plans that met

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[24]The problem can also be mitigated by allowing smaller bidders to make "non-competitive bids", that is, to state inelastic demands for which they pay the average winning price.

[25]For example, I (together with Peter Cramton and Eric Maskin) have advised the U.K. government to pick an ascending or uniform-price design for its upcoming greenhouse-gas emissions-permits auction; encouraging sufficient entry will be a key concern, and good marketing will also be very important.

[26]If this is known in advance, a negotiation with the monopsony buyer may be more appropriate than an auction.

a quality threshold, and the incumbent operator was able to work out that no-one else had developed such plans. Much the same happened in Scotland, where the only bidder for the Central region generously bid one-seventh of one penny per capita.

Here switching to an ascending auction, for example, would have done no better (probably worse in many regions, because of the non-trivial entry costs, see Sections 2B (i) - (iii)). While several elements of the design could have been improved, the most glaring problem was the inadequate reserve price.[27]

C. Other Issues

Of course, not all auction "failures" are due to collusion or entry/predation problems.

(i) Political Problems

Some "failures" are perceived more than real. For example, a second-price sealed-bid auction—in which the winner pays the runner-up's bid—can be embarrasing for the auctioneer if the winner's actual bid is revealed to be far more than the runner-up's, even if the auction was ex-ante both efficient and revenue maximizing.

McMillan (1994) reports a second-price New Zealand auction in which the winner bid NZ $7 million but paid the runner-up's bid of NZ $5,000. Of course, a reserve price should probably have been imposed, but if an appropriate reserve price had been used this might have been an economically, but not politically, sensible auction.

First-price sealed-bid auctions, by contrast can be embarrasing either for a winning bidder who pays a lot more than the second bid, or for a loser who just narrowly underbids the winner. So firms, or at least their managers, can oppose first-price auctions.

(ii) Thinking Carefully Through the Rules

Other failures are due to not thinking through the rules carefully.

For example, Turkey last year auctioned two telecom licenses sequentially, with an additional twist that set the reserve price for the second license equal to the selling price of the first. One firm then bid far more for the first license than it could possibly be worth if the firm had to compete with a rival holding the second license. But the firm had rightly figured that no rival would be willing to bid that high for the second license, which therefore remained unsold, leaving the firm without a rival operating the second license!

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[27]Important disclaimer While I have advised the U.K. government on several auctions, I have never had anything to do with TV licenses!

As another example, McMillan (1994) reports on an Australian auction for satellite-television licenses in which two bidders each made large numbers of different bids on the same objects and then, after considerable delays, defaulted on those bids they did not like after the fact—the government had neglected to impose any default penalties.

More recently the U.S. spectrum auctions have been plagued by bidders "winning" licenses and subsequently defaulting on their commitments, often after long delays. (India also recently fell into the same trap.) If default costs are small, then bidders are bidding for options on prizes rather than the prizes themselves. Furthermore, if smaller, under-financed firms can avoid commitments through bankruptcy, then the auction favors these bidders over better-financed competitors.

Auctioneers must think carefully about the gaming opportunities that their rules permit.

(iii) Credibility of the Rules

The importance of the credibility of the rules also deserves emphasis.

Sections 2A (iv) and 2B (iv) explained that rules against collusion and predation may lack credibility when there are too few bidders, but the problem of credibility is a much broader one.

For example, if after a nominally first-price sealed-bid auction the auctioneer can change his mind and accept higher offers, the auction is really an ascending-bid auction and needs to be recognised as such. So genuine sealed-bid auctions may be difficult to run in takeover battles, especially since a director who turns down a higher bid for his company after running a "sealed-bid auction" may be vulnerable to shareholder lawsuits. The famous RJR-Nabisco sale went through several supposedly-final sealed-bid auctions (Burrough and Helyar (1990)), and this might have been part of the difficulty faced by Wellcome, see Section 2B (i). Sealed-bid auctions might also be hard to commit to in the U.K. TV rights auctions, see Section 2B (iii), especially if BSkyB took over Manchester United in which case the auctioneer (the Football League) would be closely associated with a bidder. Excuses for not accepting a winning bid can often be found after the fact, whatever precommitments are attempted in advance.

Credibility may be a particular problem for governments which cannot bind their successors (or even themselves); it is difficult to effectively auction a license if the government may change the regulatory regime ex-post.

The credibility of reserve prices is of special importance. If a reserve price is not a genuine commitment to not sell an object if it does not reach its reserve, then it has no meaning and bidders will treat it as such.

For example, returning to the Turkish tale of woe of Section 2C (ii), the government is now considering new arrangements to sell the second license, but at what cost to the credibility of its future auctions?

D. When is Auction Design Less Important?

So issues such as clear and credible rules and political acceptibility of the results are important, but otherwise the main problems of auction design are those of dealing with monopsony and oligopsony power. They are **not** the information-theoretic issues such as "affiliation" that have received a great deal of study in the economic literature.

The fact that monopsony and oligopsony power is the key to auction problems also suggests that auction design may not matter very much when there is a large number of potential bidders for whom entry to the auction is easy.

Consider, for example, the sales of government securities or of commodities such as gold. Though much ink has been spilt on these subjects, auction design may not matter much for either price or efficiency. Indeed the U.S. Treasury's recent experiments with using uniform price auctions in place of discriminatory auctions yielded inconclusive results (Simon (1994), Malvey, Archibald and Flynn (1996), Nyborg and Sundaresan (1996), Reinhart and Belzar (1996), and Ausubel and Cramton (1998)), and the broader empirical literature comparing auction forms for government-security sales is also inconclusive. See Klemperer (2000b) for more discussion.[28]

3. Solutions

So ascending auctions can often support both collusive and predatory activity. To some extent the ascending auction can be "patched up". Bidders can be forced to bid "round" numbers, or the exact increments can be pre-specified, and bids can be made anonymous to make signalling hard. Lots can be aggregated into larger packages to make it harder for bidders to divide the spoils. And higher reserve prices both directly protect against a low-price outcome, and reduce firms' incentives to coordinate on a quick end to the bidding. But these measures neither eliminate the "collusion" problem, nor do anything about the "entry" concern.

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[28]Of course, even small differences in auction performance can be significant when very large amounts of money are involved, and collusion has been an issue in some government security sales.

Since I 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.

On the other hand, an ascending auction is also particularly likely to allocate the prizes to the bidders who value them the most,[29] at least among the bidders who show up, and if inefficient collusion can be avoided. The intuition is just that a bidder with a higher value always has the opportunity to rebid to top a lower-value bidder who may initially have bid more aggressively. (This applies in many "common-values" as well as "private-values" settings (Maskin, 1992).) In addition, if there are complementarities between the objects for sale, an ascending auction 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. (Allowing resale is not a perfect substitute for an efficient initial allocation, because resale is itself generally inefficient. See Myerson and Satterthwaite (1983) and Cramton, Gibbons, and Klemperer (1987).)

Furthermore, the fact that an ascending auction allows bidders to learn about others' valuations during the auction can both make the bidders more comfortable with their own assessments and often raises the auctioneer's revenues if information is "affiliated" and collusion and predation are absent (Milgrom and Weber (1982)).

So what should an auction designer do?

We assume governments (as well as other auctioneers) care not only about efficiency, but also about revenue—which is most impacted by collusion and predation—because of the substantial deadweight losses of raising government funds through alternative methods.[30]

A. The Anglo-Dutch Auction

One solution to the dilemma of choosing between the ascending (often called "English") and sealed-bid (or "Dutch") forms is to combine the two in a hybrid, the "Anglo-Dutch", which often captures the best features of both, and was first described and proposed in Klemperer (1998).

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

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[29]This 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.

[30]Feldstein (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. A deadweight loss of (?) 30c per dollar raised is a more typical estimate.

Of course, bidders lobby governments—sometimes successfully—for auction forms that minimise revenue.

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 (see Sections 2B (i), (iii)).[31] 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 also makes collusion harder than in a pure ascending auction (see Section 2A (iv)). In particular, it eliminates the final stage of the ascending auction, when just one excess bidder remains, in which phase an ascending auction is particularly vulnerable to collusive and predatory behavior (see Sections 2A (iv), 2B (iv)).

And using an Anglo-Dutch auction reduces the incentives for firms to form consortia prior to the auction (see Section 2B (v)), since if strong firms form a consortium, they may simply attract new firms into the bidding in the hope of beating the consortium in the sealed-bid round.

Furthermore, we conjecture that the ascending stages 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 making bidders more comfortable with their own assessments and raising revenues if bidders' information is "affiliated". At the same time the sealed-bid stage of the Anglo-Dutch may—we conjecture—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 (Klemperer (2000a)). All these benefits of the Anglo-Dutch auction would apply even if it attracts no additional firms into the bidding.[32]

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[31]The auction might even attract bidders who simply hope to resell. See note R.

[32]The conjectures of this paragraph need further research to confirm.

The Anglo-Dutch auction can be extended to multi-object contexts, including contexts in which individual bidders are permitted to win multiple units.[33]   In these cases it has the additional advantage of making tacit collusion in the auction much harder than in a pure ascending auction; 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 (see Sections 2 A (i), (ii)).   Furthermore, 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.

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

B. Improved Anti-trust

Effective anti-trust policy is critical to fighting collusion and predation in auctions.   But anti-trust enforcement seems much lighter than in "ordinary" economic markets.

Although the U.S. Department of Justice has successfully prosecuted some signalling behaviour similar to that described in Section 2A (ii), the legal status of this kind of behaviour remains ambiguous.   Furthermore, collusive bidding in takeover battles for companies appears to be legal in the U.S..   European anti-trust has been even weaker, as evidenced by T-Mobil's willingness to explicitly confirm the signalling behaviour described in Section 2A (i).[34]   True, when apparently similar behaviour was observed in the more recent German 3G spectrum auction (see Section 4E), the firms engaging in it refused to officially confirm that they were signalling to rivals to end the auction.[35]   But the German regulators showed no interest whatsoever in pursuing the matter.

Even more damaging, has been the European authorities' acceptance of joint-bidding agreements that are, in effect, explicit collusion (as in the recent 3G auctions, see Sections 2B (v),

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[33]With N >1 homogenous objects of which bidders are allowed to win just one each, the ascending stage will typically continue until N+1 bidders remain, but then there is a choice between a discriminatory and a uniform price (but using the Nth price not the N+1st price) sealed-bid stage.   The uniform price will probably be preferred by bidders, but this may be politically risky if the winners' bid are all revealed (c.f. Section 2C (i)). (One simple way to run a uniform Nth price auction without revealing this information would be to isolate the N+1 bidders from each other and run an ascending auction, keeping the first quit secret from the other bidders, stopping the auction only when the second quit is announced to the auctioneer, and then selling to the N winners (including the second quitter) at the final price.)

For heterogenous objects, see, for example, Section 4A and note M.

If bidders are allowed to win multiple objects, see Klemperer (1998), etc.

[34]This kind of signalling behaviour could perhaps be challenged as an abuse of "joint dominance" under EC and UK law.

[35]Even so, the Financial Times 3/11/00 p. 21, reported "One operator has privately admitted to altering the last digit of its bid in a semi-serious attempt to signal to other participants that it was willing to accept [fewer lots to end the auction]."

4B, 4D, etc.).[36]

The Antitrust agencies' response to predation in auction markets has been still more feeble.

Consider, for example, how anti-competitive the behaviour described in Sections 2B (iii) would seem in a normal competition-policy context in which dominant firms are threatened by new entry into their markets. Glaxo's statement that it "would almost certainly top a rival bid", would roughly translate to saying it "would almost certainly undercut any new entrant's price", while Pacific Telephone's remark that "if somebody takes California away from us, they'll never make any money" seems to correspond to threatening that "if anyone tries to compete with us, we'll cut the price until they lose money." And Pacific Telephone's hiring of 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 of entering new markets to potential entrants.

Would any of these "predatory" behaviours be acceptable in "normal" economic markets?

Regulators as well as auction-designers, need to treat auction markets more like "ordinary" economic markets.

4. Case Study: The Year 2000 European 3G Auctions

Although the first draft of this paper was written prior to all but the U.K.'s 3G auction, the year 2000 European third-generation mobile spectrum license auctions offer a nice case study of how good auction design must be sensitive to the context.

Of the six auctions, only the U.K. and German auctions could be called successes (see Table 1), and the German authorities were very lucky.

(A) The UK Auction (March-April)[37]

The U.K. originally planned to auction just four third-generation licenses. In this case the presence of exactly four incumbent operators who were thought to have advantages over other

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[36]Combinations agreed very close to the auction date (as in Switzerland, see Section 2B (v)) should be particularly discouraged since they give no time for entrants to emerge to threaten the "collusion".

One view is that auction participants should generally be restricted to entities that exist when the auction is first announced, but exceptions would clearly be necessary.

Combinations should often have to wait until after the auction, just as the sale of Orange to France Telecom waited until after the U.K.'s auction. For example, 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. (See Sections 4A, 4B.)

[37]I was the principal auction theorist advising the Radiocommunications 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.

bidders[38] 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.[39] 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.[40] The design performed extremely well, both in terms of efficiency and revenue generation, in laboratory experiments commissioned by the Radiocommunications Agency and by potential bidders.

However, when it became possible to auction five licences, a straightfoward ascending auction was no longer counterindicated, even though there were non-trivial entry costs and a limited number of potential bidders. 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.[41]

It helped that the U.K. was the first in the world to auction the 3G spectrum so that it was particularly unclear which new entrant(s) might be successful, and this made it easier to persuade a large number to play the game. Going to market first was a deliberate strategy of the U.K. auction team,[42] and the fact that planning had begun in 1997 for a 2000 auction also meant that there was time for a sustained marketing campaign to attract entrants.

So the problems of collusion and entry deterrence that this paper has emphasized were minimal in the U.K. context, and efficiency considerations militated towards an ascending

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[38]BT, One2One, Orange and Vodafone were the existing operators and were 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.

[39]Efficiency was the main concern of the U.K. government. More precisely, the Government's stated objectives were 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.

[40][Note M] In this case it was proposed that all four winners would pay the fourth-highest sealed 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.

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

[42]A deliberate decision was made to maintain this strategy even when the complications engendered by the Vodafone-Mannesman takeover battle led many to suggest that the U.K. auction be postponed.

design.[43]

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 ($22.5 billion) revenues.

(B) The Netherlands Auction (July)

The Netherlands' blunder was to follow the actual British design when there were five incumbent operators and five licenses in the Netherlands. The equal numbers of incumbents and licenses created exactly the situation in which this paper (Sections 2B (i)-(iii)) predicts that very few entrants will show up. (Indeed the first draft of this paper, published on my website and quoted in the Dutch press prior to the auction, did predict exactly this problem for the Netherlands.) Recognizing their weak positions, the potential new entrants made deals with incumbent operators (c.f. Section 2B (v)), and Netherlands competition policy was as disfunctional as the auction design, allowing firms such as Deutsche Telekom, DoCoMo and Hutchison, who were all strong established players in other markets than the Netherlands, to partner with the local incumbents.[44]

In the end there was just one relatively weak entrant (Versatel) to compete with the five incumbents for the five licenses. As described in Section 2B (iv), Versatel stopped bidding after receiving a threatening letter from one of the incumbents, and the auction raised less than one third of the per-capita revenue of the U.K. auction, that is, less than Fl 6 billion, rather than the almost Fl 20 billion the Dutch government had forecast based on the U.K. experience.

It seems likely that a version of the Anglo-Dutch design would have worked better. Assuming the same entrants, there are strong reasons to believe Versatel would have bid higher in the sealed-bid stage than the price at which it quit the ascending auction. And of course the fear of this would have made the incumbents bid higher. Furthermore, the "hope and dream"

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[43]In 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).)

[44]A slightly different view was that the weakest incumbent, Ben, was not much stronger than the most determined potential entrants, Deutsche Telekom and Hutchinson. This view, too, is consistent with these firms being keen to form consortia prior to an ascending auction (but not being so keen if the auction had had a sealed-bid component—see Sections 2B (v) and 3A). In fact, Ben joined with Deutsche Telekom, while Hutchinson joined with the incumbent KPN and with DoCoMo.

This view might place relatively more of the blame for the auction's failure on the weak anti-trust policy, and relatively less of the blame on the ascending design.

that the sealed-bid stage would give weaker bidders might have attracted more bidders and/or discouraged the formation of the joint-bidding consortia.

(C) The Italian Auction (October)

The Italian government thought they had learned from the Netherlands fiasco. They also chose roughly the U.K. design, but proposed that if the number of bidders who satisfied various prequalification conditions that tested their seriousness was not more than the number of licenses on offer, then the number of licenses on offer would be reduced. At first glance this seemed a clever way to avoid an embarrassingly uncompetitive auction à la Netherlands, but the plan was fundamentally flawed.

First, it is "putting the cart before the horse" to artificially create an unnecessarily concentrated mobile-phone market in order to make an auction look good.[45] The right approach, of course, is to increase the likely number of bidders by choosing an auction design that is more attractive to entry and by restricting joint bidding.[46]

Second, it is clear from our earlier discussion (especially Sections 2A (iv), 2B (iv)), that a rule that allows the possibility that there will be just one more bidder than the number of licenses does **not** guarantee a competitive ascending auction!

In the end six bidders entered the auction to compete for five licenses and one, Blu, then quit after less than two days of bidding. The final prices were only just above the starting price, resulting in per capita revenues of less than 40% of the U.K. level, or L 26,750 billion instead of the L 50,000 billion that the government had estimated.[47],[48] While the Italian government might have been luckier,[49] it was clear in advance that the design was not robust.

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[45]Furthermore if spectrum is withdrawn from the auction and it is not clear what will subsequently happen to it, this might lead to an inefficient auction outcome.

[46]The rule we are discussing may reduce the attractiveness of joint bidding, but joint bidding should be restricted directly.

[47]Some believed that there might have been some implicit "collusion" between some firms by which Blu entered simply to avoid invoking the rule reducing the number of licenses, thus allowing every other bidder to win a cheap license, and magistrates in Rome investigated possible market rigging but found no evidence. Of course, if illegal collusion was a concern, this is a further argument against the ascending design used (see Section 2A (iv)).

(Blu was a joint venture between British Telecom and Italian-based firms whose main business was not in telecoms, and they were apparently unable to agree terms for competing seriously in the auction. See, for example, Financial Times p.27, 25/10/00.)

[48]The Italian government did not take full advantage of the information from the U.K. and German auctions to set an appropriate reserve price, though their reserve price was not as absurdly low as that set by the Netherlands, Germany, Austria and Switzerland.

[49]Contrast with the Netherlands where failure seemed very probable because the number of incumbent operators equalled the number of bidders (especially after a joint bidding agreement between Deutsche Telekom and Ben made all the incumbents seem strong). So in the Netherlands I predicted that failure was probable and very strongly criticised the design in print and in press interviews in advance of the auction. In Italy I was

Again, an Anglo-Dutch design would probably have performed much better. Assuming the same entrants, the auction would have immediately moved to a "best and final" sealed-bid. The five strong bidders would have been unsure just how weak Blu was, so would have felt forced to make serious bids in case Blu did produce a good offer. And the Anglo-Dutch format might also have attracted more entry, and so further increased the competitiveness of the auction.[50] Most likely the winners would have been the same firms, but the Italian government would have received revenues much closer to the U.K. levels, as it had predicted.

(D) The Swiss Auction (November/December)

Switzerland again copied the U.K. design and achieved by far the lowest per capita revenues of all the year 2000 3G auctions, a result that is only to a very tiny degree explained by its small population. Instead it was due to the ascending design, inadequate anti-trust policy, and a reserve price that was set absurdly low given the information available from the preceding European 3G auctions. As explained in Section 2B (v), the result was complete fiasco. Only four bidders showed up for four licenses (an Anglo-Dutch auction might have retained more bidders) so the bidders had just to pay the reserve price—one-thirtieth per capita of the U.K. and German prices.[51]

(E) The German Auction (July-August)

The Germans conformed to national habits (or at least to British stereotypes of them) by choosing a more complex design: Germany auctioned twelve blocks of spectrum from which bidders could create "licenses" of either two or three blocks, e.g., four firms could win large 3-block licenses or six firms could win smaller 2-block licenses. The twelve blocks were sold by simultaneous auction.

In the event only seven bidders participated (entry was perhaps discouraged by the ascending design), and of these one (Debitel) looked quite weak. Debitel's resolve might have been further weakened by the what-looked-like-a-collusive offer from a rival discussed in Section 2A (iv).

When Debitel dropped out at just over 60% of the per-capita revenue achieved by the UK auction there were then two natural outcomes, depending on the strategies followed by the two dominant incumbents (Deutsche Telekom and Vodafone-Mannesman, each of whom had

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more cautious, though I wrote before the auction that a different auction design should have been chosen, and I emphasised the advantages of a sealed-bid component in a speech in Rome three months before to the auction.

[50]Deutsche Telekom (a winner in the U.K., Netherlands, and Germany) did not enter the Italian contest. Furthermore, the Italian government eliminated two weak bidders prior to the auction. This was probably a mistake, and even if these weak bidders might have made little difference to an ascending auction, they might well have scared the stronger bidders into more aggressive bidding in a "sealed-bid" contest.

[51]A week before the auction a government official estimated receipts at two-thirds of the per capita U.K. and German levels; other estimates were higher. The government postponed the auction for a month while it tried to change the rules, but concluded it was legally obliged to stick to the original rules.

about 40% of the existing German mobile market). Either these dominant firms could raise the price to force the weaker firms among the remaining six to quit, which would yield high revenue for the government but a concentrated industry. Or they could lead all six remaining firms to reduce their demands to two blocks each, thus ending the auction quickly and giving the government a lowish revenue but an unconcentrated industry (c.f. Section 2A (v)).

Vodafone-Mannesman ended a number of its bids with the digit "6" which, it is generally believed, was a signal that its preference was to end the auction quickly with six remaining bidders (c.f. their behaviour described in Section 2A (i)).

Surprisingly, however, Deutsche Telekom first continued to push up the price while it was at levels that the weaker firms had shown themselves willing to pay in the U.K. auction, but then ended the auction before pushing any of the weaker firms out, giving up just when the price approached the level at which the weaker players had quit the U.K. auction.[52],[53] Some have wondered whether DT's objectives were affected by the fact that it was majority owned by the German government. In any case, the government ended up with both high revenues (almost 98% of the U.K. revenues per capita) and an unconcentrated (six-firm) mobile-phones market!

However, the fragility of the German design was emphasized by the sequel in Austria.[54]

(F) The Austrian Auction (November)

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[52]Deutsche Telekom's behaviour reminds me of my father-in-law whom I often see join a queue but quit in frustration before the front of the line. Rational behaviour generally involves sizing up the queue first, and then either quitting quickly (c.f. ending the auction quickly) or gritting one's teeth and waiting to the end (c.f. waiting for another firm to quit the auction). See the related discussion in Section 2A (v).

[53]Given that DT had pushed up the price so far, should Vodafone-Mannesman now have changed its strategy and continued pushing the price up further? Possibly. However, if V-M, only, had successfully continued to demand three blocks and driven a weaker bidder out, the rules would then have required the re-auction of a block (see next note) with unpredictable results, and DT might have ended up with three blocks at a much lower price than V-M, an outcome which V-M's management probably wished to avoid. Furthermore, V-M may have retained its pessimistic views about the cost of driving out a weaker firm. In any case, V-M co-operated with DT in ending the auction.

[54]The problems we have emphasised were by no means the only flaws of the German auction design.

For example, a bidder might have stayed in the auction in the hope of being one of five winners, but suddenly found itself one of six winners, and been quite unhappy in this event, and even tried to default. (In fact, the bidding behaviour and other evidence suggests that all the winners were indeed happy to win.)

Furthermore, the possibility that the auction would end with a bidder being the high bidder on just a single block, in which case the rules called for the block to be re-auctioned, created both considerable uncertainty for bidders and the possibility of an inefficient allocation, since the price in the re-auction could be very different from that in the original auction. (Again, the government was lucky that this seemed not to create inefficiency in practise.)

The auction also had a second stage in which additional spectrum was auctioned to the first-stage winners. This was not a success; the five bidders who were interested quickly coordinated on taking one block each of the five available blocks (bidders were permitted to win multiple blocks) at the very-low reserve price.

Austria exactly mimicked the German design (again conforming to national habits?) Again interest in entering an ascending auction was limited, and just six firms competed for the twelve blocks available. As described in Section 2A (v), the excessively low reserve price made it easy to predict that the firms would tacitly agree to share the market so that each received two blocks at (close to) the reserve price. Bidders paid one-sixth of the U.K. and German per capita revenues.

(G) Lessons

The generally lower prices of the later auctions in part reflected a dramatic cooling of market sentiment towards 3G prospects (and technology stocks in general), which also raised firms' costs of capital when their budgets had been depleted by earlier auctions. But only in part. Just one week before the Swiss auction (the last of the year) was due to begin, analysts were still forecasting prices of 400-600 Euros per capita and though this was a discount on previous predictions, it was a very far cry from the outcome of 20. And of course the Netherlands' catastrophe was sandwiched between the British and German successes.

In part, also, the firms become cleverer at playing the game, just as firms seemed to become more successful at achieving lower prices in the later U.S. FCC auctions (Cramton and Schwarz, 2000).[55] But mainly governments were stupider, and less well-prepared, hastily copying previous designs in circumstances to which they were unsuited.

The European 3G auctions show very clearly that auction design is not "one size fits all". The ascending design that worked very well for the U.K. worked very badly in the Netherlands, Italy, and Switzerland because of entry problems, and this was predictable (and predicted) in advance.

The Anglo-Dutch design—that the U.K. would have used if entry had been a concern there—would clearly have worked better for the other countries.

The entry problems of the later auctions were greatly exacerbated by permitting joint-bidding agreements prior to the auction, and by failing to use the information from the U.K. and German auctions to set sensible reserve prices.

The German and Austrian auctions demonstrated the vulnerability of ascending auctions to "collusive" behaviour during the auctions.

5. Market Structure

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[55]And just as in competition policy, restricting some aspect of firms' behaviour may lower prices for a while until firms learn some new way to tacitly coordinate.

Our paper has addressed problems of conduct, especially collusion and predation. But competition authorities also analyse the merits of mergers and other changes to market structure.

In many auctions, such as those of oil, gold, financial instruments, etc., there is very little issue about market structure. But when auctioning mobile-phone licenses, for example, the structure of the industry that will be created cannot be ignored by an auction designer any more than it can be ignored by an ordinary industry regulator.[56]

It is tempting to simply "let the market decide" the industry structure by auctioning many small packages of spectrum which individual firms can aggregate into larger licenses. But the auction's outcome is driven by bidders' profits, not by final consumers' (or social) welfare, so the outcome of such an auction will be distorted from the social viewpoint.

The most obvious distortion is that since bidders' joint profits in the market being created will be maximised by a monopoly, too few firms will win spectrum, and these winners will each win too much (exactly as a "hands-off" policy to merger control will tend to create an overly-concentrated industry). The Turkish fiasco (see Section 2C (ii)) was a spectacular example of how an auction can be biased towards generating monopoly.

But we have also seen that in a multiunit ascending auction (or in a uniform price auction) there is an offsetting effect, since firms can "collude" to divide the spoils at a low price. Even without "collusion", that is, taking other players' bidding limits as given, a firm with a large demand knows it can end the auction at a lower price by reducing its own demands, see, especially Ausubel and Cramton (1998). So in this case it is possible for too many firms to each win too little spectrum, and all that can definitely be said is that there is no presumption that the number of winners will be socially efficient.

So, for example, the German government probably made a mistake in auctioning twelve small blocks of spectrum in its 3G auction (see Section 4E). Since the bidding in the British auction had demonstrated that bidders believed that there was sufficient spectrum in Germany for six companies to operate there, the government should probably simply have auctioned six licenses. Although this was in fact the eventual outcome, the German government's complex design risked obtaining an overly concentrated mobile-phone market (Jehiel and Moldovanu (2000a, b)).

Of course, regulators are not always better than even a distorted market process in determining market structure. Just as a main reason for preferring auctions to "beauty contests" (administrative procedures) for allocating licenses is that companies have access to information

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[56]Another example is that the most important issues in regulating the sale of U.K. football TV rights are: What packages are sold?, and How many packages is a single broadcaster allowed to win?

about the value of the licenses that is unavailable to regulators, regulators may also lack the information to determine the correct market structure. Just as auction design is not "one size fits all", there can also be no general rule about whether market structure should be determined endogenously or exogenously to the auction.

6. Conclusion

None of the preceding should be taken as an argument against auctions. Most auctions work extremely well. They are generally quicker and more "transparent" (so less open to political and legal challenges), more likely to achieve an efficient allocation, and raise more revenue than administrative hearings ("beauty contests"), see e.g. Klemperer (2000b). Indeed even "unsuccessful" auctions, such as the Netherlands, Italian and Austrian spectrum auctions we discussed, were probably at least as successful as beauty contests would have been, and as the beauty contests organized by Spain, Sweden and France.

But auction design does matter when the number of potential bidders is limited. In this case, the most important features of an auction are that it be robust against collusion and attractive to potential bidders.

Furthermore, auction design is not "one size fits all". While the ascending auction is very risky in many contexts (and an Anglo-Dutch auction may perform better), it has also been used very successfully in other contexts.

The recent round of European third generation spectrum auctions confirms that good auction design is very sensitive to the details of the environment. Other governments would be foolish not to copy the U.S. and U.K. in auctioning the radiospectrum, but they would be equally foolish to blindly follow past designs without attention to their local circumstances.

In auction design, the devil is in the details.

References

Anton, James J. and Dennis A. Yao. 1992. "Coordination of Split Award Auctions." Quarterly Journal of Economics. 107, pp. 681-701.

Ausubel, Lawrence M. and Peter Cramton. 1998 "Demand Reduction and Inefficiency in Multi-Unit Auctions." Mimeo, University of Maryland.

Ausubel, Lawrence M. and Jessie A. Schwartz. 1999. "The Ascending Auction Paradox." Working paper, University of Maryland.

Back, Kerry and Jaime F. Zender. 1993. "Auctions of Divisible Goods." Review of Financial Studies, 6, pp. 733-64.

Back, Kerry and Jaime F. Zender. 1999. "Auctions of Divisible Goods with Endogenous Supply." Working Paper, Washington University in St. Louis and University of Arizona.

Betton, Sandra and Espen B. Eckbo. 1995. "Toeholds, competition and state-contingent payoffs: an experimental investigation." Journal of Economics and Management Strategy 6, pp. 573-603.

Bikhchandani, Sushil 1988. "Reputation in Repeated Second-Price Auctions." Journal of Economic Theory. 46, pp. 97-119.

Brusco, Sandro and Giuseppe Lopomo. 1999. "Collusion via Signalling in Open Ascending Auctions with Multiple Objects and Complementarities." Working Paper, Stern School of Business, New York University.

Bulow, Jeremy I., John D. Geanakoplos and Paul D. Klemperer. 1985a. "Multimarket Oligopoly: Strategic Substitutes and Complements." Journal of Political Economy. 93, pp. 488-511.

Bulow, Jeremy I., John D. Geanakoplos, and Paul D. Klemperer. 1985b. "Holding Idle Capacity to Deter Entry." Economic Journal. 95, pp. 178-82.

Bulow, Jeremy I., Ming Huang, and Paul D. Klemperer. 1999. "Toeholds and Takeovers." Journal of Political Economy. 107, pp. 427-54.

Bulow, Jeremy I. and Paul D. Klemperer. 1996. "Auctions vs Negotiations." American Economic Review. 86 pp. 180-94

Bulow, Jeremy I. and Paul D. Klemperer. 2000. "Prices and the Winner's Curse." Nuffield College, Oxford University Dicussion Paper, available at
www.nuff.ox.ac.uk/economics/people/klemperer.htm.

Burrough, Brian and John Helyar. 1990. Barbarians at the Gate: the fall of RJR Nabisco. London: Arrow.

Coase, Ronald H. 1959. "The Federal Communications Commission." Journal of Law and Economics. October: 2, pp. 1-40.

Cramton, Peter, Robert Gibbons and Paul D. Klemperer. 1987. "Dissolving a Partnership Efficiently." Econometrica. 55:3, pp. 615-32.

Cramton, Peter and Jessie A. Schwartz. 1999. "Collusive Bidding in the FCC Spectrum Auctions." Working paper, University of Maryland.

Cramton, Peter and Jessie A. Schwartz. 2000. "Collusive Bidding: Lessons from the FCC Spectrum Auctions." Journal of Regulatory Economics. 17, forthcoming.

Engelbrecht-Wiggans, Richard and Charles M. Kahn. 1998. "Low Revenue Equilibria in Simultaneous Auctions." Working paper, University of Illinois.

Federico, Giulio and David Rahman. 2000. "Bidding in an Electricity Pay-As-Bid Auction." Working paper, Nuffield College.

Fehr, Nils-Henrik von der and David Harbord. 1998. "Competition in Electricity Spot Markets: Economic Theory and International Experience." Memorandum No. 5/1998, Department of Economics, University of Oslo.

Feldstein, Martin. 1999. "Tax Avoidance and the Deadweight Loss of the Income Tax." The Review of Economics and Statistics. November.

Gilbert, Richard and Paul D. Klemperer. 2000. "An Equilibrium Theory of Rationing." Rand Journal of Economics. 3:1, pp. 1-21.

Hansard, 18 May 1998, written answer to UK Parliamentary Question.

Hendricks, Kenneth and Robert H. Porter. 1989. "Collusion in Auctions." Annales D'Economie et de Statistique. 15/16, pp. 217-30.

Jehiel, Phillipe and Benny Moldovanu. 2000a. "A Critique of the Planned Rules for the German UMTS/IMT-2000 License Auction." Working Paper, University College London and University of Mannheim.

Jehiel, Phillipe and Benny Moldovanu. 2000b. "License Auctions and Market Structure." Working Paper, University College London and University of Mannheim.

Klemperer, Paul D. 1998. "Auctions with Almost Common Values." European Economic Review. 42, pp. 757-69.

Klemperer, Paul D. 1999a. "Auction Theory: A Guide to the Literature." Journal of Economic Surveys. 13: 3, pp. 227-286. (Also reprinted in The Current State of Economic Science. 1999. S. Dahiya, ed. 2, pp. 711-766.)

Klemperer, Paul D. 1999b. "Applying Auction Theory to Economics." Invited Lecture to the 8th World Congress of the Econometric Society. 1999 draft.

Klemperer, Paul D. ed. 2000a The Economic Theory of Auctions. Cheltenham, UK: Edward Elgar.

Klemperer, Paul D. 2000b. "Spectrum on the Block". Wall Street Journal (Asia) 5/10/00 p. 8, at www.nuff.ox.ac.uk/economics/people/klemperer.htm

Klemperer, Paul D. 2001. "Applying Auction Theory to Economics." Invited Paper to 8th World Congress of the Econometric Society.

Klemperer, Paul D. and Margaret A. Meyer. 1989. "Supply Function Equilibria in Oligopoly Under Uncertainty." Econometrica. 57, pp. 1243-77.

Klemperer, Paul D. and Marco Pagnozzi. 2001. "Advantaged Bidders and Spectrum Prices: An Empirical Analysis."

Malvey, P. F., C. M. Archibald, and S. T. Flynn. 1996. "Uniform-Price Auctions: Evaluation of the Treasury Experience." Working Paper, U.S. Treasury.

Maskin, Eric S. 1992. "Auctions and Privatization." in Privatization. H. Siebert, ed. pp. 115-36.

McAdams, David. 1998. "Adjustable Supply and 'Collusive-Seeming Equilibria' in the Uniform-Price Share Auction." Working Paper, Stanford University.

McAfee, R. Preston and John McMillan. 1996. "Analyzing the Airwaves Auction." Journal of Economic Perspectives. 10, pp. 159-75.

McMillan, John. 1994. "Selling Spectrum Rights." Journal of Economic Perspectives. 8, pp. 145-62.

Menezes, Flavio. 1996. "Multiple-unit English auctions." European Journal of Political Economy. 12, pp. 671-684.

Milgrom, Paul R. 1987. "Auction Theory," in Advances in Economic Theory: Fifth World Congress. Truman F. Bewley, ed. Cambridge: Cambridge University Press.

Milgrom, Paul R. Forthcoming. Putting Auction Theory to Work. Cambridge: Cambridge University Press.

Milgrom, Paul R. and Robert J. Weber. 1982. "A Theory of Auctions and Competitive Bidding." Econometrica. 50, pp. 1089-1122.

Myerson, Roger B. and Mark A. Satterthwaite. 1983. "Efficient Mechanisms for Bilateral Trade." Journal of Economic Theory. 29, pp. 265-81.

Newbery, David M. 1998. "Competition, Contracts, and Entry in the Electricity Spot Market." The RAND Journal of Economics. 29:4, pp. 726-49.

Nyborg, Kjell G. 1997. "On Complicity in Share Auctions." Mimeo, London Business School.

Nyborg, Kjell and Suresh Sundaresan. 1996. "Discriminatory Versus Uniform Treasury Auctions: Evidence from When-Issued Transactions." Journal of Financial Economics. 42, pp. 63-104.

Office of Gas and Electricity Markets. 1999. The New Electricity Trading Arrangements, July, available at www.open.gov.uk/offer/reta.htm

Radiocommunications Agency. 1998a. UMTS Auction Design. UMTS Auction Consultative Group paper 14 of 1998, available as UACG(98)14 at www.spectrumauctions.gov.uk

Radiocommunications Agency. 1998b. UMTS Auction Design 2. UMTS Auction Consultative Group paper 16 of 1998, available as UACG(98)16 at www.spectrumauctions.gov.uk

Reinhert, V. and G. Belzer. 1996. "Some Evidence on Bid Sharing and the Use of Information in the U.S. Treasury's Auction Experiment." Working Paper, Board of Governors of the Federal Reserve System.

Riley, John G. and Huagang Li. 1997. "Auction Choice: A Numerical Analysis." Mimeo, University of California at Los Angeles.

Robinson, Marc S. 1985. "Collusion and the Choice of Auction." Rand Journal of Economics. 16, pp. 141-45.

Simon, D. 1994. "The Treasury's Experiment with Single-Price Auctions in the Mid-1970's: Winner's or Taxpayer's Curse?" Review of Economics and Statistics. 76, pp. 754-760.

U.K. Monopolies and Mergers Commission. 1999. British Sky Broadcasting Group and Manchester United: A report on the proposed merger. Cm 4305. London: The Stationery Office.

Vickrey, William. 1961. "Counterspeculation, Auctions, and Competitive Sealed Tenders." Journal of Finance. 16, pp. 8-37.

Vickrey, William. 1976. "Auctions Markets and Optimum Allocations." In Bidding and Auctioning for Procurement and Allocation. Studies in Game Theory and Mathematical Economics. Yakov Amihud, ed. New York: New York University Press. pp. 13-20.

Weber, Robert J. 1997. "Making More from Less: Strategic Demand Reduction in the FCC Spectrum Auctions." Journal of Economics and Management Strategy. 6:3, pp. 529-48.

Wilson, Robert 1979. "Auctions of Shares." Quarterly Journal of Economics. 93, pp. 675-89.

Wolfram, Catherine D. 1998. "Strategic Bidding in a Multiunit Auction: An Empirical Analysis of Bids to Supply Electricity in England and Wales." The RAND Journal of Economics, 29:4, pp. 703-25.

Wolfram, Catherine D. 1999. "Measuring Duopoly Power in the British Electricity Spot Market." American Economic Review. 89, pp. 805-826.

Revenues from European 3G Mobile Spectrum Auctions
completed in 2000

Euros per capita[57]

Austria	100
Germany	615
Italy	240
Netherlands	170
Switzerland	20
UK	630

TABLE 1

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[57]Per capita revenue is typically used as a simple measure. Of course other factors matter. For example, Germany's large per capita GNP, large size, central location facilitating expansion to other markets, and low current mobile penetration, were all said to increase its per capita value. The precise date of sale also mattered, since market sentiment towards 3G become dramatically less optimistic over the period of the auctions, and this also increased bidders' costs of capital. Nevertheless, analysts were still estimating 400-600 Euros per capita from the Swiss auction (the last of these auctions) in the week before that auction was due to begin.