# Using and Abusing Auction Theory*

*Economic theory is often abused in practical policy-making. There is frequently excessive focus on sophisticated theory at the expense of elementary theory; too much economic knowledge can sometimes be a dangerous thing. Too little attention is paid to the wider economic context, and to the dangers posed by political pressures. Superficially trivial distinctions between policy proposals may be economically significant, while economically irrelevant distinctions may be politically important. I illustrate with some disastrous government auctions, but also show the value of economic theory.*

## 4.1 INTRODUCTION

For half a century or more after the publication of his *Principles* (1890), it was routinely asserted of economic ideas that "they're all in Marshall". Of course, that is no longer true of the theory itself. But Marshall was also very concerned with applying economics, and when we think about how to use the theory, the example that Marshall set still remains a valuable guide. In this chapter, therefore, I want to use some of Marshall's views, and my own experience in auction design, to discuss the use (and abuse) of economic theory.[1]

[1] This is the text of the 2002 Alfred Marshall Lecture of the European Economic Association, given at its Annual Congress, in Venice.

I gave a similar lecture at the 2002 Colin Clark Lecture of the Econometric Society, presented to its Annual Australasian Meeting. Like Marshall, Clark was very involved in practical economic policy making. He stressed the importance of quantification of empirical facts which, I argue below, is often underemphasized by modern economic theorists.

Similar material also formed the core of the biennial 2002 Lim Tay Boh Lecture in Singapore. Lim was another very distinguished economist (and Vice-Chancellor of the National University of Singapore), who also made significant contributions to policy, as an advisor to the Singapore Government.

Finally, some of these ideas were presented in the Keynote Address to the 2002 Portuguese Economic Association's 2002 meetings.

I am very grateful to all those audiences for helpful comments.

Although the most elegant mathematical theory is often the most influential, it may not be the most useful for practical problems. Marshall (1906) famously stated that "a good mathematical theorem dealing with economic hypotheses [is] very unlikely to be good economics", and continued by asserting the rules "(1) Translate [mathematics] into English; (2) then illustrate by examples that are important in real life; (3) burn the mathematics; (4) if you can't succeed in 2, burn 1"! Certainly this view now seems extreme, but it is salutary to be reminded that good mathematics need not necessarily be good economics. To slightly update Marshall's rules, if we cannot (1) offer credible intuition and (2) supply empirical (or perhaps case-study or experimental) evidence, we should (4) be cautious about applying the theory in practice.[2]

Furthermore, when economics is applied to policy, proposals need to be robust to the political context in which they are intended to operate. Too many economists excuse their practical failure by saying "the politicians (or bureaucrats) didn't do exactly what I recommended". Just as medical practitioners must allow for the fact that their patients may not take all the pills they prescribe, or follow all the advice they are given, so economics practitioners need to foresee political and administrative pressures and make their plans robust to changes that politicians, bureaucrats, and lobbyists are likely to impose. And in framing proposals, economists must recognize that policies that seem identical, or almost identical, to them may seem very different to politicians, and vice versa.

Some academics also need to widen the scope of their analyses beyond the confines of their models which, while elegant, are often short on real-world detail. Marshall always emphasized the importance of a deep "historical knowledge of any area being investigated and referred again and again to the complexity of economic problems and the naivety of simple hypotheses."[3] Employing "know it all" consultants with narrowly focused theories instead of experienced people with a good knowledge of the wider context can sometimes lead to disaster.

One might think these lessons scarcely needed stating—and Marshall certainly understood them very well—but the sorry history of "expert" advice in some recent auctions shows that they bear repetition. So although the lessons are general ones, I will illustrate them using auctions and auction theory: Auction theory is often held up as a triumph of the application of economic theory to economic practice, but it has not, in truth, been an unalloyed success. For example, while the European and Asian 3G spectrum auctions famously raised over 100 billion euros in

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[2] I mean cautious about the theory. Not dismissive of it. And (3) seems a self-evident mistake, if only because of the need for efficient communication among, and education of, economists, let alone the possibilities for further useful development of the mathematics.

[3] Sills (1968, p. 28). An attractively written appreciation of Marshall and his work is in Keynes (1933).

total revenues, Hong Kong's, Austria's, the Netherlands', and Switzerland's auctions, among others, were catastrophically badly run yielding only a quarter or less of the per capita revenues earned elsewhere—and economic theorists deserve some of the blame.[4,5] Hong Kong's auction, for example, was superficially well designed, but not robust to relatively slight political interference that should perhaps have been anticipated. Several countries' academic advisors failed to recognize the importance of the interaction between different countries' auction processes, and bidders advised by experts in auction theory who ignored (or were ignorant of) their clients' histories pursued strategies that cost them billions of euros. Many of these failures could have been avoided if the lessons had been learnt to: pay more attention to elementary theory, to the wider context of the auctions, and to political pressures—and pay less attention to sophisticated mathematical theory.[6]

Of course, mathematical theory, even when it has no direct practical application, is not merely beautiful. It can clarify the central features of a problem, provide useful benchmarks and starting points for analysis and—especially—show the deep relationships between problems that are superficially unconnected. Thus, for example, the sophisticated tools of auction theory that have sometimes been abused in practical contexts turn out to have valuable applications to problems that, at first blush, do not look like auctions.

Section 4.2 briefly discusses what is often taken to be the ''standard auction theory'', before discussing its real relevance. Sections 4.3–4.5 illustrate its abuse using examples from the Asian and European 3G auctions, and discuss the broader lessons that can be drawn from these misapplications. Section 4.3 is in large part based on Klemperer (2000b) and chapters

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[4] We take the governments' desire for high revenue as given, and ask how well the auctions met this objective. While an efficient allocation of licenses was most governments' first priority, there is no clear evidence of any differences between the efficiencies of different countries' allocations, so revenues were seen as the measure of success. Section 6.2 argues that governments were correct to make revenue a priority because of the substantial deadweight losses of raising government funds by alternative means, and because the revenues were one-time sunk costs for firms so should be expected to have only limited effects on firms' subsequent investment and pricing behavior.)

[5] The six European auctions in year 2000 yielded 100 (Austria), 615 (Germany), 240 (Italy), 170 (Netherlands), 20 (Switzerland), and 650 (United Kingdom) euros per capita for very similar properties. True, valuations fell during the year as the stockmarkets also fell, but chapter 5 details a variety of evidence that valuations ranged from 300 to 700 euros per capita in all of these auctions. Chapter 5 gives a full description of all nine west European 3G auctions.

[6] Another topical example of overemphasis on sophisticated theory at the expense of elementary theory is European merger policy's heavy focus on the "coordinated" effects that may be facilitated by a merger (and about which we have learnt from repeated game theory) and, at the time of writing, relative lack of concern about the more straightforward "unilateral" effects of mergers (which can be understood using much simpler static game theory). (As a UK Competition Commissioner, I stress that this criticism does not apply to UK policy!)

3 and 5 where additional details can be found (and this section may be skipped by readers familiar with all that material) but the other sections make different points using additional examples. Section 4.6 illustrates how the same concepts that are abused can have surprisingly valuable uses in different contexts. Section 4.7 concludes.


## 4.2 THE RECEIVED AUCTION THEORY

The core result that everyone who studies auction theory learns is the remarkable *Revenue Equivalence Theorem* (RET).[7] This tells us, subject to some reasonable-sounding conditions, that all the standard (and many non-standard) auction mechanisms are equally profitable for the seller, and that buyers are also indifferent between all these mechanisms.

If that were all there was to it, auction design would be of no interest. But of course the RET rests on a number of assumptions. Probably the most influential piece of auction theory apart from those associated with the RET is Milgrom and Weber's (1982a) remarkable paper—it is surely no coincidence that this is also perhaps the most elegant piece of auction theory apart from the RET. Milgrom and Weber's seminal analysis relaxes the assumption that bidders have independent private information about the value of the object for sale, and instead assumes bidders' private information is *affiliated*. This is similar to assuming positive correlation,[8] and under this assumption they show that ordinary ascending auctions are more profitable than standard (first-price) sealed-bid auctions, in expectation.

Milgrom and Weber's beautiful work is undoubtedly an important piece of economic theory and it has been enormously influential.[9] As a result, many economists leave graduate school "knowing" two things about auctions. First, that if bidders' information is independent then all auctions are equally good, and second, that if information is affiliated (which is

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[7] The RET is due in an early form to Vickrey (1961), and in its full glory to Myerson (1981), Riley and Samuelson (1981), and others. A typical statement is "Assume each of a given number of risk-neutral potential buyers has a privately known signal about the value of an object, independently drawn from a common, strictly increasing, atomless distribution. Then any auction mechanism in which (i) the object always goes to the buyer with the highest signal, and (ii) any bidder with the lowest feasible signal expects zero surplus, yields the same expected revenue (and results in each bidder making the same expected payment as a function of her signal)."

See chapter 1 for further discussion of the RET.

[8] Affiliation is actually a stronger assumption, but it is probably typically approximately satisfied.

[9] Not only is the concept of affiliation important in applications well beyond auction theory (see section 4.6) but this paper was also critical to the development of auction theory, in that it introduced and analyzed a general model including both private and common value components.

generally the plausible case) then the ascending auction maximizes the seller's revenue.[10] But is this correct?

### 4.2.1 Relevance of the Received Theory

Marshall's (updated) tests are a good place to start. The value of empirical evidence needs no defense, while examining the plausibility of an intuition helps check whether an economic model provides a useful caricature of the real world, or misleads us by absurdly exaggerating particular features of it.[11]

The intuition behind the exact RET result cannot, to my knowledge, be explained in words that are both accurate and comprehensible to lay people. Anyone with the technical skill to understand any verbal explanation would probably do so by translating the words back into the mathematical argument. But it is easier to defend the weaker claim that it is ambiguous which of the two most common auction forms is superior: it *is* easy to explain that participants in a sealed-bid auction shade their bids below their values (unlike in an ascending auction), but that the winner determines the price (unlike in an ascending auction), so it is not hard to be convincing that there is no clear reason why either auction should be more profitable than the other. This is not quite the same as arguing that the standard auction forms are approximately similarly profitable, but the approximate validity of the RET (under its key assumptions) in fact seems consistent with the available evidence. (Some would say that the mere fact that both the ascending auction and the sealed-bid auction are commonly observed in practice is evidence that neither is always superior.) So the "approximate RET" seems a reasonable claim in practice, and it then follows that issues assumed away by the RET's assumptions should be looked at to choose between the standard auction forms. These issues should include not just those made explicitly in the statement of the theorem, for example, bidders are symmetric and risk-neutral; but also those that are implicit, for example, bidders share common priors and play non-cooperative Nash equilibrium; or semi-implicit, for example, the number and types of bidders are independent of the auction form.

However, as already noted, much attention has focused on just one of the RET's assumptions, namely independence of the bidders' information, and the theoretical result that if information is non-independent (affiliated) then ascending auctions are more profitable than first-price sealed-bid auctions. There is no very compelling intuition for this result. The verbal explanations that are given

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[10] Or, to take just one very typical example from a current academic article "The one useful thing that our single unit auction theory can tell us is that when bidders' [signals] are affiliated … the English [i.e., ascending] auction should be expected to raise the most revenue."

[11] Whether the intuition need be non-mathematical, or even comprehensible to lay people, depends on the context, but we can surely have greater confidence in predicting agents' actions when the agents concerned understand the logic behind them, especially when there are few opportunities for learning.

are unconvincing and/or misleading, or worse. The most commonly given "explanation" is that ascending auctions allow bidders to be more aggressive, because their "winner's curses" are reduced,[12] but this argument is plain wrong: the winner's curse is only a feature of common-value auctions, but common values are neither necessary nor sufficient for the result.[13]

A better explanation of the theoretical result is that bidders' profits derive from their private information, and the auctioneer can profit by reducing that private information.[14] An ascending auction reveals the information of bidders who drop out early, so partially reveals the winner's information (if bidders' information is correlated), and uses that information to set the price (through the runner-up's bid), whereas the price paid in a sealed-bid auction cannot use that information. Since the ascending and sealed-bid auctions are revenue-equivalent absent any correlation (i.e., with independent signals), and provided the runner-up's bid responds to the additional information that an ascending auction reveals in the appropriate way (which it does when information is affiliated), this effect makes the ascending auction the more profitable. Of course, this argument is obviously still incomplete,[15,16] and even if it

[12] The "winner's curse" reflects the fact that winning an auction suggests one's opponents have pessimistic views about the value of the prize, and bidders must take this into account by bidding more conservatively than otherwise.

[13] The result applies with affiliated private values, in which bidders' values are unaffected by others' information, so there is no winner's curse, and the result does not apply to independent-signal common-value auctions which do suffer from the winner's curse. (Where there is a winner's curse, the "theory" behind the argument is that bidders' private information can be inferred from the points at which they drop out of an ascending auction, so less "bad news" is discovered at the moment of winning than is discovered in winning a sealed-bid auction, so bidders can bid more aggressively in an ascending auction. But this assumes that bidders' more aggressive bidding more than compensates for the reduced winner's curse in an ascending auction—in independent-signal common-value auctions it exactly compensates, which is why there is no net effect, as the RET proves.)

In fact, many experimental and empirical studies suggest bidders fail to fully account for winner's curse effects, so these effects may in practice make sealed-bid auctions more profitable than ascending auctions!

[14] Absent private information, the auctioneer would sell to the bidder with the highest expected valuation at that expected valuation, and bidders would earn no rents. The more general result that, on average, the selling price is increased by having it depend on as much information as possible about the value of the good, is Milgrom and Weber's (1982a, 2000) Linkage Principle. However, in more recent work, Perry and Reny (1999) show that the Principle applies less generally (even in theory) than was thought.

[15] Revealing more information clearly need not necessarily reduce bidders' profits (if bidders' information is negatively correlated, the contrary is typically true), the conditions that make the ascending price respond correctly to the additional information revealed are quite subtle, and nor does the argument say anything about how affiliation affects sealed bids. Indeed there are simple and not unnatural examples with the "wrong kind" of positive correlation in which the ranking of auctions' revenues is reversed (see Bulow and Klemperer, forthcoming), and Perry and Reny (1999) also show the trickiness of the argument by demonstrating that the result only holds for single-unit auctions. A more complete verbal argument for the theoretical result is given in Appendix 1.C, but it is very hard (certainly for the layman).

were fully convincing, it would depend on the *exact* RET applying—which seems a very strong claim.

Furthermore, before relying on any theory mattering in practice, we need to ask: what is the likely order of magnitude of the effect? In fact, numerical analysis suggests the effects of affiliation are often tiny, even when bidders who exactly fit the assumptions of the theory compute their bids exactly using the theory. Riley and Li (1997) analyze equilibrium in a natural class of examples and show that the revenue difference between ascending and first-price auctions is very small unless the information is very strongly affiliated: when bidders' values are jointly normally distributed, bidders' expected rents are about 10 percent (20 percent) higher in a sealed-bid auction than in an ascending auction even for correlation coefficients as high as 0.3 (0.5). So these results suggest affiliation could explain why a 3G spectrum auction earned, for example, 640 rather than 650 euros per capita when bidders' valuations were 700 euros per capita. But the actual range was from just 20 (*twenty*) to 650 euros per capita! Riley and Li also find that even with very strong affiliation, other effects, such as those of asymmetry, are more important and often reverse the effects of affiliation, even taking the numbers of bidders, non-cooperative behavior, common priors, etc., as given.[17] This kind of quantitative analysis surely deserves more attention than economists often give it.

[16] Another loose intuition is that in an ascending auction each bidder acts as if he is competing against an opponent with the same valuation. But in a sealed-bid auction a bidder must outbid those with lower valuations. With independent valuations, the RET applies. But if valuations are affiliated, a lower valuation bidder has a more conservative estimate of his opponent's valuation and therefore bids more conservatively. So a bidder in a sealed-bid auction attempting to outbid lower-valuation bidders will bid more conservatively as well. But this argument also rests on the RET applying exactly, and even so several steps are either far from compelling (e.g., the optimal bid against a more conservative opponent is not always to be more conservative), or very non-transparent.

[17] An easier numerical example than Riley and Li's assumes bidder $i$'s value is $v_i = \theta + t_i$, in which $\theta$ and the $t_i$'s are independent and uniform on [0, 1], and $i$ knows only $v_i$. With two bidders, expected revenue is 14/18 in a first-price sealed-bid auction and 15/18 in an ascending auction, so bidder rents are 7/18 and 6/18 respectively (though with $n$ bidders of whom $n/2$ each win a single object, as $n \to \infty$ bidder rents are 42 percent higher in the sealed-bid auction).

With very extreme affiliation, an auctioneer's profits may be more sensitive to the auction form. Modifying the previous example so that there are two bidders who have completely diffuse priors for $\theta$, bidder rents are 50 percent higher in a first-price sealed-bid auction than in an ascending auction (see Appendix 1.D), and Riley and Li's example yields a similar result for correlation coefficients around 0.9 (when bidder rents are anyway small). These examples assume private values. Auctioneers' profits may also be more sensitive to auction form with common values and, in the previous extreme-affiliation model with diffuse priors on $\theta$, if bidders' signals are $v_i$ and the true common value is $\theta$, bidders' rents are twice as high in the sealed-bid auction as in the ascending auction. But, with common values, small asymmetries between bidders are very much more important than affiliation (see Klemperer, 1998; Bulow and Klemperer, 2002). Moreover, we will see that other effects also seem to have been quantitatively much more important in practice than affiliation is even in any of these theoretical examples.

Finally, all the previous discussion is in the context of single-unit auctions. Perry and Reny (1999) show that the result about affiliation does not hold—even in theory—in multi-unit auctions.[18]

Given all this, it is unsurprising that there is no empirical evidence (that I am aware of) that argues the affiliation effect is important.[19,20]

So there seems no strong argument to expect affiliation to matter much in most practical applications; independence is not the assumption of the RET that most needs relaxing.

The theory that really matters most for auction design is just the very elementary undergraduate economics of relaxing the implicit and semi-implicit assumptions of the RET about (fixed) entry and (lack of) collusion.[21] The intuitions are (as Marshall says they should be) easy to explain—we will see that it is clear that bidders are likely to understand and therefore to follow the undergraduate theory. By contrast the intuition for affiliation gives no sense of how bidders should compute their bids, and the calculations required to do so optimally require considerable mathematical sophistication and are sensitive to the precise assumptions bidders make about the ''prior'' distributions from which their and others' private information is drawn. Of course, this does not mean agents cannot intuitively make approximately optimal decisions (Machlup, 1946; Friedman, 1953), and individual agents need not understand the intuitions behind equilibrium group outcomes. But we can be more confident in predicting that agents will make decisions whose logic is very clear, especially in one-off events such as many auctions are.

Not surprisingly, practical examples of the undergraduate theory are easy to give (as Marshall also insists). But there is no elegant theory applying to the specific context of auctions; such theory is unnecessary since the basic point is that the main concerns in auctions are just the same as in other economic markets, so much of the same theory applies (see below). Furthermore, some

[18] The RET, also, only generalizes to a limited extent to multi-unit auctions.

[19] For example, empirical evidence about timber sales suggests rough revenue equivalence, or even that the sealed-bid auction raises more revenue given the number of bidders (Hansen, 1986; Mead and Schneipp, 1989; Paarsch, 1991; Rothkopf and Engelbrecht-Wiggans, 1993; Haile, 1996) though information is probably affiliated. The experimental evidence (see Kagel and Roth, 1995; Levin, Kagel, and Richard, 1996) is also inconclusive about whether affiliation causes any difference between the revenues from ascending and sealed-bid auctions.

[20] Like Marshall, Colin Clark (1939) emphasized the importance of quantification and real-world facts (see note 1), writing "I have … left my former colleagues in the English Universities … with dismay at their continued preference for the theoretical … approach to economic problems. Not one in a hundred … seems to understand [the need for] the testing of conclusions against … observed facts…" "…The result is a vast output of literature of which, it is safe to say, scarcely a syllable will be read in fifty years' time." I think he would be pleased that an academic from an English University is quoting his syllables well over 50 years after he wrote them.

[21] See chapter 3 and section 4.3. Risk-aversion and asymmetries (even absent entry issues) also arguably matter more than affiliation (and usually have the opposite effect). It is striking that Maskin and Riley's (1984, 2000b) important papers on these topics (see also Matthews, 1983, etc.) failed to have the same broad impact as Milgrom and Weber's work on affiliation.

of the key concerns are especially prominent when the assumption of symmetry is dropped, and models with asymmetries are often inelegant.

So graduate students are taught the elegant mathematics of affiliation and whenever, and wherever, I give a seminar about auctions in practice,[22] I am asked a question along the lines of "Haven't Milgrom and Weber shown that ascending auctions raise most revenue, so why consider other alternatives?". This is true of seminars to academics. It is even more true of seminars to policy makers. Thus, although a little knowledge of economic theory is a good thing, too much knowledge can sometimes be a dangerous thing. Moreover, the extraordinary influence of the concept of affiliation is only the most important example of this. I give a further illustration, involving over-attention to some of my own work, in the next subsection. In short, a little graduate education in auction theory can often distract attention from the straightforward "undergraduate" issues that really matter.[23]

### 4.3 THE ELEMENTARY ECONOMIC THEORY THAT MATTERS

What really matters in practical auction design is robustness against collusion and attractiveness to entry—just as in ordinary industrial markets.[24] Since I have repeatedly argued this, much of this section is drawn from Klemperer (2000b) and chapters 3 and 5 (any reader familiar with all this material may wish to skip to section 4.4).

#### 4.3.1 Entry

The received theory described above takes the number of bidders as given. But the profitability of an auction depends crucially on the number of bidders who participate, and different auctions vary enormously in their

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[22] I have done this in over twenty countries in five continents.

[23] True, the generally accepted notion of the "received auction theory" is changing and so is the auction theory that is emphasized in graduate programs. And recent auctions research has been heavily influenced by practical problems. But it will probably remain true that the elegance of a theory will remain an important determinant of its practical influence.

[24] Of course, auction theorists have not altogether ignored these issues—but the emphasis on them has been far less. The literature on collusion includes Robinson (1985), Cramton, Gibbons, and Klemperer (1987), Graham and Marshall (1987), Milgrom (1987), Hendricks and Porter (1989), Graham, Marshall, and Richard (1990), Mailath and Zemsky (1991), McAfee and McMillan (1992), Menezes (1996), Weber (1997), Engelbrecht-Wiggans and Kahn (1998c), Ausubel and Schwartz (1999), Brusco and Lopomo (2002a), Hendricks, Porter, and Tan (1999) and Cramton and Schwartz (2000). That on entry includes Matthews (1984), Engelbrecht-Wiggans (1987), McAfee and McMillan (1987c, 1988), Harstad (1990), Engelbrecht-Wiggans (1993), Levin and Smith (1994), Bulow and Klemperer (1996), Menezes and Monteiro (2000), Persico (2000b), Klemperer (1998) and Gilbert and Klemperer (2000). See also sections 1.8, 1.9 and the Afterword to chapter 1.

attractiveness to entry; participating in an auction can be a costly exercise that bidders will only undertake if they feel they have realistic chances of winning. In an ascending auction a stronger bidder can always top any bid that a weaker bidder makes, and knowing this the weaker bidder may not enter the auction in the first place—which may then allow the stronger bidder to win at a very low price. In a first-price sealed-bid auction, by contrast, a weaker bidder may win at a price that the stronger bidder could have beaten, but did not because the stronger bidder may risk trying to win at a lower price and cannot change his bid later. So more bidders may enter a first-price sealed-bid auction.[25]

The intuition is very clear, and there is little need for sophisticated theory. Perhaps because of this, or because the argument depends on asymmetries between bidders so any theory is likely to be inelegant, theory has largely ignored the point. Vickrey's (1961) classic paper contains an example (relegated to an appendix, and often overlooked) which illustrates the basic point that the player who actually has the lower value may win a first-price sealed-bid auction in Nash equilibrium, but that this cannot happen in an ascending auction (with private values). But little has been said since.

In fact, some of what has been written about the issue of attracting entry provides a further illustration of the potentially perverse impact of sophisticated theory. Although the point that weaker bidders are unlikely to win ascending auctions, and may therefore not enter them, is very general, some work—including Klemperer (1998)[26]—has emphasized that the argument is especially compelling for "almost-common-value" auctions, and this work may have had the unintended side-effect of linking the entry concern to common values in some people's minds;[27] I have heard economists who know the latter work all too well say that because an auction does not involve common values, therefore there is no entry problem![28] To the extent that the almost-common values theory (which is both of more limited application, and also assumes quite sophisticated reasoning by bidders) has distracted attention from the more general point, this is another example of excessive focus on sophisticated theory at the expense of more elementary, but more crucial, theory.

[25] The point is similar to the industrial-organization point that because a Bertrand market is more competitive than a Cournot market for any given number of firms, the Bertrand market may attract less entry, so the Cournot market may be more competitive if the number of firms is endogenous.

[26] See also Bikhchandani (1988), Bulow, Huang, and Klemperer (1999), Bulow and Klemperer (2002), and Klemperer and Pagnozzi (forthcoming).

[27] In spite of the fact that I have made the point that the argument applies more broadly in, for example, Klemperer (1999b, 2000b). See also sections 2.3.1, 3.3, and Gilbert and Klemperer (2000).

[28] Similarly others have asserted that the reason the United Kingdom planned to include a sealed-bid component in its 3G design if only four licenses were available for sale (see below), was because the auction designers (who included me) thought the auction was almost-common values—but publicly available government documents show that we did not think this was likely.

There is an additional important reason why a first-price sealed-bid auction may be more attractive to entrants: bidders in a sealed-bid auction may be much less certain about opponents' strategies, and the advantage of stronger players may therefore be less pronounced, than standard equilibrium theory predicts. The reason is that in practice, players are not likely to share common priors about distributions of valuations and, even if they do, they may not play Nash equilibrium strategies (i.e., a sealed-bid auction induces "strategic uncertainty"). So even if players were in fact ex-ante symmetric (i.e., their private information is drawn from identical distributions) the lower-value player might win a first-price sealed-bid auction, but would never win an ascending auction (in which bidders' strategies are very straightforward and predictable). When players are not symmetric, Nash equilibrium theory predicts that a weaker player will sometimes beat a stronger player in a sealed-bid auction, but I conjecture strategic uncertainty and the absence of common priors make this outcome even more likely than Nash equilibrium predicts. Since this point is very hard for standard economic theory to capture, it has largely been passed over. But it reinforces the point that a sealed-bid auction is in many circumstances more likely than an ascending auction to attract entry, and this will often have a substantial effect on the relative profit-abilities of the auctions.

The 3G auctions provide good examples of over-sensitivity to the significance of information revelation and affiliation at the expense of insensitivity to the more important issue of entry. For example, the Netherlands sold five 3G licenses in a context in which there were also exactly five incumbent mobile-phone operators who were the natural winners, leaving no room for any entrant. (For competition-policy reasons, bidders were permitted to win no more than one license each). The problem of attracting enough entry to have a competitive auction should therefore have been uppermost in planners' minds. But the planners seem instead to have been seduced by the fact that ascending auctions raise (a little) extra revenue because of affiliation and also increase the likelihood of an efficient allocation to those with the highest valuations.[29] The planners were probably also influenced by the fact that previous spectrum auctions in the United States and United Kingdom had used ascending designs,[30] even though they had usually done so in contexts in which entry was less

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[29] It seems unlikely that the efficiency of the Netherlands auction was much improved by the ascending design.

[30] We discuss the UK design below. The design of the US auctions, according to McMillan (1994, p. 151–2) who was a consultant to the US government, was largely determined by faith in the linkage principle and hence in the revenue advantages of an ascending auction in the presence of affiliation; the economic theorists advising the government judged other potential problems with the ascending design "to be outweighed by the bidders' ability to learn from other bids in the auction" (McMillan, 1994) (see also Perry and Reny, 1999). Efficiency was also a concern in the design of the US auctions.

of a concern, and even though some US auctions did suffer from entry problems. The result of the Netherlands auction was both predictable, and predicted (see, e.g. Maasland (2000) and Klemperer (2000b) quoted in the Dutch press prior to the auction). There was no serious entrant.[31] Revenue was less than a third of what had been predicted and barely a quarter of the per capita amounts raised in the immediately preceding and immediately subsequent 3G auctions (in the United Kingdom and Germany respectively). The resulting furor in the press led to a Parliamentary Inquiry.

By contrast, when Denmark faced a very similar situation in its 3G auctions in late 2001—four licenses for sale and four incumbents—its primary concern was to encourage entry.[32] (The designers had both observed the Netherlands fiasco, and also read Klemperer (2000b).) It chose a sealed-bid design (a "fourth-price" auction) and had a resounding success. A serious entrant bid, and revenue far exceeded expectations and was more than twice the levels achieved by any of the other three European 3G auctions (Switzerland, Belgium and Greece) that took place since late 2000.

The academics who designed the UK sale (which was held prior to the Netherlands and Danish auctions) also thought much harder about entry into their 3G auction.[33] The United Kingdom had four incumbent operators, and when design work began it was unclear how many licenses it would be possible to offer given the technological constraints. We realized that if there were just four licenses available it would be hard to persuade a non-incumbent to enter, so we planned in that case to use a design including a sealed-bid component (an "Anglo-Dutch" design) to encourage entry. In the event, five licenses were available so, given the UK context, we switched to an ascending auction, since there was considerable uncertainty about who the fifth strongest bidder would be (we ran the

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[31] There was one entrant who probably did not seriously expect to win a license in an ascending auction—indeed it argued strongly prior to the auction that an ascending auction gave it very little chance and, more generally, reduced the likelihood of entry into the auction. Perhaps it competed in the hope of being bought off by an incumbent by, for example, gaining access rights to an incumbent's network, in return for its quitting the auction early. The Netherlands government should be very grateful that this entrant competed for as long as it did! See section 5.3.2 and van Damme (2002) for more details.

[32] Attracting entry was an even more severe problem in late 2001 than in early summer 2000 when the Netherlands auction was held. The dotcom boom was over, European telecoms stock prices at the time of the Danish auction were just one-third the levels they were at in the Dutch auction, and the prospects for 3G were much dimmer than they had seemed previously.

[33] I was the principal auction theorist advising the Radiocommunications Agency which designed and ran the UK auction. Ken Binmore led the team and supervised experiments testing the proposed designs. Other academic advisors included Tilman Börgers, Jeremy Bulow, Philippe Jehiel and Joe Swierzbinksi. Ken Binmore subsequently advised the Danish government on its very successful auction. The views expressed in this chapter are mine alone.

world's first 3G auction in part to ensure this; see section 4.5).[34] Thirteen bidders entered, ensuring a highly competitive auction which resulted in the highest per capita revenue among all the European and Asian 3G auctions.

### 4.3.2 Collusion

The received auction theory also assumes bidders play non-cooperatively in Nash equilibrium. We have already discussed how Nash equilibrium may be a poor prediction because of "strategic uncertainty" and the failure of the common priors assumption, but a more fundamental problem is that players may behave collusively rather than non-cooperatively. In particular, a standard ascending auction—especially a multi-unit ascending auction— often satisfies *all* the conditions that elementary economic theory tells us are important for facilitating collusion, even without any possibility of interaction or discussion among bidders beyond the information communicated in their bids.

For example, Waterson's (1984) standard industrial organization textbook lists five questions that must be answered affirmatively for firms to be able to support collusion in an ordinary industrial market: (1) can firms easily identify efficient divisions of the market? (2) Can firms easily agree on a division? (3) Can firms easily detect defection from any agreement? (4) Can firms credibly punish any observed defection? (5) Can firms deter non-participants in the agreement from entering the industry? In a multi-unit ascending auction: (1) the objects for sale are well defined, so firms can see how to share the collusive "pie" among them (by contrast with the problem of sharing an industrial market whose definition may not be obvious); (2) bids can be used to signal proposals about how the division should be made and to signal agreement; 3) firms' pricing (i.e., bidding) is immediately and perfectly observable, so defection from any collusive agreement is immediately detected; (4) the threat of punishment for defection from the agreement is highly credible, since punishment is quick and easy and often costless to the punisher in a multi-object auction in which a player has the ability to raise the price only on objects that the defector

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[34] With five licenses, the licenses would be of unequal size, which argued for an ascending design. Note that in some contexts an ascending design may promote entry. For example, when Peter Cramton, Eric Maskin, and I advised the UK government on the design of its March 2002 auction of reductions in greenhouse gas emissions, we recommended an ascending design to encourage the entry of small bidders for whom working out how to bid sensibly in a discriminatory sealed-bid auction might have been prohibitively costly. (Strictly speaking the auction was a descending one since the auction was a reverse auction in which firms were bidding to sell emissions reductions to the government. But this is equivalent to an ascending design for a standard auction to sell permits.) (Larry Ausubel and Jeremy Bulow were also involved in the implementation of this design.) See Klemperer et al. (forthcoming).

will win;[35] and (5) we have already argued that entry in an ascending auction may be hard.

So collusion in an ascending auction seems much easier to sustain than in an "ordinary" industrial market, and it should therefore be no surprise that ascending auctions provide some particularly clear examples of collusion, as we illustrate below.

By contrast, a first-price sealed-bid auction is usually much more robust to collusion: bidders cannot "exchange views" through their bids, or observe opponents' bids until after the auction is over, or punish defection from any agreement during the course of the auction, or easily deter entry. But, perhaps because auction theorists have little that is new or exciting to say about collusion, too little attention has been given to this elementary issue in practical applications.

In the Austrian 3G auction, for example, twelve identical blocks of spectrum were sold to six bidders in a simultaneous ascending auction (bidders were allowed to win multiple blocks each). No one was in the least surprised when the bidding stopped just above the low reserve price with each bidder winning two blocks, at perhaps one-third the price that bidders valued them at.[36] Clearly the effect of "collusion" (whether explicit and illegal, or tacit and possibly legal) on revenues is first-order.

Another elegant example of bidders' ability to "collude" is provided by the 1999 German DCS-1800 auction in which ten blocks of spectrum were sold by ascending auction, with the rule that any new bid on a block had to exceed the previous high bid by at least 10 percent.[37] There were just two credible bidders, the two largest German mobile-phone companies T-Mobil and Mannesman, and Mannesman's first bids were 18.18 million deutschmarks per megahertz on blocks 1–5 and 20 million deutschmarks per MHz on blocks 6–10. T-Mobil—who bid even less in the first round—later said "There were no agreements with Mannesman. But [we] interpreted

[35] For example, in a multi-license US spectrum auction in 1996–97, U.S. West was competing vigorously with McLeod for lot number 378, a license in Rochester, Minnesota. Although most bids in the auction had been in exact thousands of dollars, U.S. West bid $313,378 and $62,378 for two licenses in Iowa in which it had earlier shown no interest, overbidding McLeod, who had seemed to be the uncontested high-bidder for these licenses. McLeod got the point that it was being punished for competing in Rochester, and dropped out of that market. Since McLeod made subsequent higher bids on the Iowa licenses, the "punishment" bids cost U.S. West nothing (Cramton and Schwartz, 2000).

[36] Although it did not require rocket science to determine the obvious way to divide twelve among six, the largest incumbent, Telekom Austria probably assisted the coordination when it announced in advance of the auction that it "would be satisfied with just two of the 12 blocks of frequency on offer" and "if the [five other bidders] behaved similarly it should be possible to get the frequencies on sensible terms", but "it would bid for a third frequency block if one of its rivals did" (Crossland, 2000).

[37] Unlike my other examples in this chapter this was not a 3G auction; however, it is highly relevant to the German 3G auction which we will discuss.

Mannesman's first bid as an offer.'' (Stuewe, 1999, p. 13). The point is that 18.18 plus a 10 percent raise equals 20.00. It seems T-Mobil understood that if it bid 20 million deutschmarks 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, which was a small fraction of the valuations that the bidders actually placed on the blocks.[38]

This example makes another important point. The elementary theory that tells us that ''collusion'' is easy in this context is important. The reader may think it obvious that bidders can ''collude'' in the setting described, but that is because the reader has been exposed to elementary undergraduate economic theory. This point was beautifully illustrated by the behavior of the subjects in an experiment that was specifically designed to advise one of the bidders in this auction by mimicking its setting and rules: the experimental subjects completely failed to achieve the low-price ''collusive'' outcome that was achieved in practice. Instead ''… in [all] the [experimental] sessions the bidding was very competitive. Subjects went for all ten units in the beginning, and typically reduced their bidding rights only when the budget limit forced them to do so'' (Abbink, Irlenbusch, Rockenbach, Sadrieh, and Selten, 2002). So the elementary economic theory of collusion which makes it plain, by contrast, that the ''collusive'' outcome that actually arose was to be expected from more sophisticated players does matter—and I feel confident that the very distinguished economists who ran the experiments advised their bidder more on the basis of the elementary theory than on the basis of the experiments.[39]

Both the United Kingdom's and Denmark's academic advisors gave considerable thought to preventing collusion. Denmark, for example, not only ran a sealed-bid auction, but also allowed bidders to submit multiple bids at multiple locations with the rule that only the highest bid made by any bidder would count, and also arranged for phony bids to be submitted—the idea was that bidders could not (illegally) agree to observe each other's bids without fear that their partners in collusion would double-

[38] See Jehiel and Moldovanu (2001b) and Grimm, Riedel, and Wolfstetter (2003). Grimm et al. argue that this outcome was a non-cooperative Nash equilibrium of the fully specified game. This is similar to the familiar industrial organization point that oligopolistic outcomes that we call ''collusive'' may be Nash equilibria of repeated oligopoly games. But our focus is on whether outcomes look like competitive, non-cooperative, behavior in the simple analyses that are often made, not on whether or not they can be justified as Nash equilibria in more sophisticated models.

[39] Abbink, Irlenbusch, Rockenbach, Sadrieh, and Selten (2002) write ''The lessons learnt from the experiments are complemented by theoretical strategic considerations''. Indeed, auctions policy advice should always, if possible, be informed by both theory and experiments.

cross them, and nor could bidders observe who had made bids, or how many had been made.[40]


## 4.4 ROBUSTNESS TO POLITICAL PRESSURES

To be effective, economic advice must also be sensitive to the organizational and political context; it is important to be realistic about how advice will be acted on. Economic advisors commonly explain a policy failure with the excuse that "it would have been okay if they had followed our advice". But medical practitioners are expected to take account of the fact that patients will not follow their every instruction.[41] Why should economic practitioners be different? Maybe it should be regarded as economic malpractice to give advice that will actually make matters worse if it is not followed exactly.

For example, the economic theorists advising the Swiss government on its 3G auction favored a multi-unit ascending auction, apparently arguing along the standard received- auction-theory lines that this was best for both efficiency and revenue. But they recognized the dangers of such an auction encouraging "collusive" behavior and deterring entry, and the advisors therefore also proposed setting a high reserve price. This would not only directly limit the potential revenue losses from collusion and/or inadequate entry but, importantly, also reduce the likelihood of collusion. (With a high reserve price, bidders are relatively more likely to prefer to raise the price to attempt to drive their rivals out altogether, than to collude with them at the reserve price; see section 3.4.1; Brusco and Lopomo, 2002b.)

But serious reserve prices are often unpopular with politicians and bureaucrats who—even if they have the information to set them sensibly—are often reluctant to run even a tiny risk of not selling the objects, which outcome they fear would be seen as "a failure".

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[40] In the United Kingdom's ascending auction, the fact that bidders were each restricted to winning at most a single object, out of just five objects, ruled out tacit collusion to divide the spoils (provided that there were more than five bidders). More important, the large number of bidders expected (because the United Kingdom ran Europe's first 3G auction; see section 4.5) also made explicit (illegal) collusion much less likely (see chapter 5) and the fact that the United Kingdom retained the right to cancel the auction in some circumstances also reduced bidders' incentive to collude.

[41] Doctors are trained to recognize that some types of patients may not take all prescribed medicines or return for follow-up treatment. Pharmaceutical companies have developed one-dose regimens that are often more expensive or less effective than multiple-dose treatments, but that overcome these specific problems. For example, the treatment of chlamydial infection by a single dose of azithromycin is much more expensive and no more effective than a 7 day course of doxycycline; there is a short (2 month) course of preventive therapy for tuberculosis that is both more expensive, and seems to have more problems with side effects, than the longer 6 month course; and the abridged regimen for HIV+ women who are pregnant (to prevent perinatal transmission) is less effective than the longer, more extensive treatment.

The upshot was that no serious reserve was set. Through exit, joint-venture, and possibly—it was rumored—collusion,[42] the number of bidders shrank to equal the number of licenses available, so the remaining bidders had to pay only the trivial reserve price that had been fixed. (Firms were allowed to win just a single license each.) The outcome was met with jubilation by the bidders and their shareholders; per capita revenues were easily the lowest of any of the nine western European 3G auctions, and less than one-thirtieth of what the government had been hoping for.[43] Perhaps an ascending auction together with a carefully chosen reserve price was a reasonable choice. But an ascending auction with only a trivial reserve price was a disaster, and the economic-theorist advisors should have been more realistic that this was a likely outcome of their advice.[44]

### 4.4.1 Economic Similarity ≠ Political Similarity

Hong Kong's auction was another case where designers should perhaps have anticipated the political response to their advice. The Hong Kong auction's designers, like Denmark's, had observed the Netherlands fiasco (and had also read Klemperer, 2000b). So they were keen to use a sealed-bid design, given Hong Kong's situation.[45] Specifically, they favored a "fourth-price" sealed-

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[42] Two bidders merged the day before the auction was to begin, and a total of five bidders quit in the last four days before the auction. At least one bidder had quit earlier after hearing from its bidding consultants that because it was a weaker bidder it had very little chance of winning an ascending auction. Furthermore, the regulator investigated rumors that Deutsche Telekom agreed not to participate in the auction in return for subsequently being able to buy into one of the winners.

[43] In fact, when the denouement of the auction had become clear, the Swiss government tried to cancel it and re-run it with different rules. But in contrast to the UK auction (see note 40), the designers had omitted to allow themselves that possibility.

The final revenues were 20 euros per capita, compared to analysts' estimates of 400–600 euros per capita in the week before the auction was due to begin. Meeks (2001) shows the jumps in Swisscom's share price around the auction are highly statistically significant and, controlling for general market movements, correspond to the market believing that bidders paid several hundred euros per capita less in the auction than was earlier anticipated.

[44] I am not arguing that an ascending auction plus reserve price is always bad advice, or even that it was necessarily poor advice here. But advisors must make it very clear if success depends on a whole package being adopted, and should think carefully about the likely implementation of their proposals.

Greece and Belgium did set reserve prices that seem to have been carefully thought out, but they were perhaps encouraged to do so by the example of the Swiss auction, and of the Italian and Austrian auctions which also had reserve prices that were clearly too low, even if not as low as Switzerland's.

[45] In Hong Kong, unlike in the Netherlands and Denmark, there were actually more incumbents than licenses. But not all Hong Kong's incumbents were thought strong. Furthermore, it is much more attractive for strong firms to form joint ventures or collude with their closest rivals prior to a standard ascending auction (when the strengthened combined bidder discourages entry) than prior to a standard sealed-bid auction (when reducing two strong bidders to one may attract entry). So even though the difference in strength between the likely winners and the also-rans seemed less dramatic in Hong Kong than in the Netherlands and Denmark, a standard ascending auction still seemed problematic. So there was a very serious concern—well-justified as it turned out—that a standard ascending auction would yield no more bidders than licenses.

bid design so that all four winners (there were four licenses and firms could win at most one license each) would pay the same fourth-highest bid—charging winners different amounts for identical properties might both be awkward and lead to cautious bidding by managements who did not want to risk the embarrassment of paying more than their rivals.[46]

However, the designers were also afraid that if the public could observe the top three bids after the auction, then if these were very different from the price that the firms actually paid (the fourth highest bid), the government would be criticized for selling the licenses for less than the firms had shown themselves willing to pay. Of course, such criticism would be ill-informed, but it could still be damaging, because even well-intentioned commentators find it hard to explain to the general public that requiring firms to pay their own bids would result in firms bidding differently. Thus far, nothing was different from the situation in Denmark. However, whereas the Danish government simply followed the advice it was given to keep all the bids secret and reveal only the price paid, the Hong Kong government felt it could not do this.

Openness and transparency of government was a big political issue in the wake of Hong Kong's return to Chinese rule, and it was feared that secrecy would be impossible to maintain. The advisors therefore proposed to run an auction that was *strategically equivalent* (i.e., has an identical game-theoretic structure and therefore should induce identical behavior) to a fourth-price auction, but that did not reveal the three high bids to *anyone*.[47] To achieve this, an ascending auction would be run for the four identical licenses, but dropouts would be kept secret and the price would continue to rise until the point at which the number of players remaining dropped from four to *three*. At this point the last four (including the firm that had just "dropped out") would pay the last price at which four players remained in the bidding. Since nothing was revealed to any player until the auction was over, no player had any decision to make except to choose a single dropout price, in the knowledge that if its price was among the top four then it would pay the fourth-highest dropout price; that is, the situation was identical from the firm's viewpoint to choosing a single bid in a fourth-price sealed-bid auction. But, unlike in Denmark, no one would ever see the "bids" planned by the top three winners

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[46] In a simple model, if a winning bidder suffers "embarrassment costs" which are an increasing function of the difference between his payment and the lowest winning payment, then bidders are no worse off in expectation than in an auction which induces no embarrassment costs, but the auctioneer suffers. This is a consequence of the revenue equivalence theorem: under its assumptions, mechanisms that induce embarrassment costs cannot affect bidders' utilities (it is irrelevant to the bidders whether the "embarrassment costs" are received by the auctioneer or are social waste), so in equilibrium winning bidders' expected payments are lower by the expected embarrassment costs they suffer. (See chapter 1, exercise 5.)

[47] I had no direct involvement with this auction but, embarrassingly, I am told this "solution" was found in a footnote to Klemperer (2000b) that pointed out this method of running a strategically equivalent auction to the uniform fourth-price auction, and that it might (sometimes) be more politically acceptable. See also note 37 to chapter 6.

(and since these bids would never even have been placed, very little credibility would have attached to reports of them).

However, although the proposed auction was mathematically (i.e., strategically) equivalent to a sealed-bid auction, its verbal description was very different. The stronger incumbents lobbied vigorously for a "small change" to the design—that the price be determined when the numbers dropped from five to four, rather than from four to three.

This is the "standard" way of running an ascending auction, and it recreates the standard problem that entry is deterred because strong players can bid aggressively in the knowledge that the winners will only pay a loser's bid (the fifth bid) and not have to pay one of the winners' bids.

Revealingly, one of the strong players that, it is said, lobbied so strongly for changing the proposal was at the same time a weaker player (a potential entrant) in the Danish market and, it is said, professed itself entirely happy with the fourth-price sealed-bid rules for *that* market.

The lobbyists' arguments that their suggested change was "small" and made the auction more "standard", and also that it was "unfair" to have the bidders continue to "bid against themselves" when there were just four left, were politically salient points, even though they are irrelevant or meaningless from a strictly game-theoretic viewpoint.[48] Since the academic consultants who proposed the original design had very little influence at the higher political levels at which the final decision was taken, and since perhaps not all the ultimate decision-makers understood—or wanted to understand—the full significance of the change, the government gave way and made it.[49]

The result? Just the four strongest bidders entered and paid the reserve price—a major disappointment for the government, and yielding perhaps one-third to one-half the revenue that had been anticipated (allowing for market conditions). Whether other potential bidders gave up altogether, or whether they made collusive agreements with stronger bidders not to enter (as was rumored in the press), is unknown. But what is certain is that the design finally chosen made entry much harder and collusion much easier.

It is not clear what the economic theorists advising should have recommended. Perhaps they should have stuck to a (fourth-price) sealed-bid auction run in the standard way, but used computer technology that could determine the price to be paid while making it impossible for anyone other than the bidders to know the other bids made.

[48] The lobbyists also successfully ridiculed the original design, calling it the "dark auction", arguing that it "perversely" hid information when "everyone knows that transparent markets are more efficient", and claiming it was an "unfair tax" since bidders "paid more than if they had all the information".

[49] The highly sophisticated security arrangements that had been made to ensure secrecy of the dropouts (removal of bidding teams to separate top-secret locations in army camps, etc.) were not altered even though they had become much less relevant; there was no need to lobby against these.

The moral, however, is clear. Auction designs that seem similar to economic theorists may seem very different to politicians, bureaucrats and the public, and vice versa. And political and lobbying pressures need to be predicted and planned for in advance.

When the designers of the UK 3G auction proposed a design—the Anglo-Dutch—that was very unattractive to the incumbent operators, it probably helped that two alternative versions of the design were initially offered. Whilst the incumbent operators hated the overall design and lobbied furiously against it,[50] they also had strong preferences between its two versions, and much of their lobbying efforts therefore focused on the choice between them. When the government selected the version the operators preferred (the designers actually preferred this version too) the operators felt they had got a part of what they had asked for, and it proved politically possible for the government to stick to the Anglo-Dutch design until the circumstances changed radically.[51]

Another notorious "political failure" was the design of the 1998 Netherlands 2G spectrum auction. The EU Commission objected to the Netherlands government's rules for the auction shortly before the (EU imposed) deadline for the allocation of the licenses. The rules were therefore quickly rewritten by a high-ranking civil servant on a Friday afternoon. The result was an auction that sold similar properties at prices that differed by a factor of about two, and almost certainly allocated the licenses inefficiently.[52]

Economists are now waking up to the importance of these issues: Wilson (2002) addresses political constraints in the design of auction markets for electricity, and Roth (2002) also discusses political aspects of market design. But the politics of design remains understudied by economic theorists, and underappreciated by them in their role as practitioners.

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[50] It is rumored that a single bidder's budget for economic advice for lobbying against the design exceeded the UK government's expenditure on economic advice during the entire three-year design process; the lobbying effort included hiring two Nobel prize winners in the hope of finding arguments against the design. See section 6.5.1 for details of the two versions of the design.

[51] When it became possible to offer an additional fifth license in the United Kingdom the design changed—as had been planned for this circumstance—to a pure ascending one (see section 4.3.1).

[52] See van Damme (1999). This auction also illustrates the potential importance of bidders' errors: although high stakes were involved (the revenues were over 800 million euros) it seems that the outcome, and perhaps also the efficiency of the license allocation, was critically affected by a bidder unintentionally losing its eligibility to bid on additional properties later in the auction; it has been suggested that the bidder's behavior can only be explained by the fact that it happened on "Carnival Monday", a day of celebrations and drinking in the south of the Netherlands where the bidder is based (van Damme, 1999)! (The German 3G auction described below provides another example of the large role that bidder error can play.)

4.5 Understanding the Wider Context

Any consultant new to a situation must beware of overlooking issues that are well understood by those with more experience of the environment. The danger is perhaps particularly acute for economic theorists who are used to seeing the world through models that, while very elegant, are often lacking in real-world detail and context.

The German 3G auction illustrates the importance of the wider context. As we described in section 4.3.2, in Germany's 1999 DCS-1800 auction Mannesman used its bids to signal to T-Mobil how the two firms should divide the blocks between them and end the auction at a comparatively low price. T-Mobil then cut back its demand in exactly the way Mannesman suggested, and Mannesman followed through with its half of the "bargain" by also cutting back its demand, so the auction ended with the two firms winning similar amounts of spectrum very cheaply.

It seems that Mannesman used the same advisors in the 3G auction that it had used in the GSM auction. Although the rules for the 3G auction were not identical, it was another simultaneous ascending auction in which individual bidders were permitted to win multiple blocks. After the number of bidders had fallen to six competing for a total of twelve blocks, and when it was clear that the other four bidders would be content with two blocks each, Mannesman apparently signaled to T-Mobil to cut back its demand to just two blocks.[53] If T-Mobil and Mannesman had both done this the auction would have ended at modest prices. Instead T-Mobil seemingly ignored Mannesman's signals, and drove up the total price 15 billion euros before cutting back demand. Once T-Mobil did cut back its demand, Mannesman followed, so the auction ended with the allocation that Mannesman had originally signaled but with each of the six firms paying an additional 2.5 billion euros!

It seems that Mannesman's advisors saw the GSM auction as a template for the 3G auction; they took the view that, following previous practice, Mannesman would signal when to reduce demand, T-Mobil would acquiesce, and Mannesman would then follow through on its half of the bargain.[54] The bargain would be enforced by firms not wishing to jeopardize their future cooperation in subsequent auctions (including 3G auctions in other countries) and in negotiating with regulators, etc. (and the short-run advantage that could

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[53] According to the *Financial Times* (3 November 2000, p. 21), "One operator has privately admitted to altering the last digit of its bid … to signal to other participants that it was willing to accept a small license."

[54] It seems that another reason why Mannesman expected the firms to coordinate by T-Mobil reducing demand first in response to Mannesman's signals was that Mannesman saw itself as the leading firm in the market. However, T-Mobil may not have seen Mannesman as the leading firm—the two firms were closely matched—and this seems to have contributed to the problem.

be gained by failing to cooperate was anyway probably small; see Klemperer, 2002 and sections 7.5–7.8). But given their expectation that T-Mobil would cut back demand first, Mannesman's advisors were unwilling to reduce demand when T-Mobil did not.

Clearly, T-Mobil's advisors saw things differently. It seems that their main advisors had not been involved in the GSM auction and the example of the previous auction was certainly not in the forefront of their minds. Instead they mistrusted Mannesman's intentions, and were very unwilling to cut back demand without proof that Mannesman had already done so. True the 3G auction was a much more complicated game than the GSM auction because of the other parties involved, and sections 5.4.1 and 7.5–7.8 discusses other factors that may have contributed to the firms' failure to reduce demand.[55] But T-Mobil's refusal to cut back demand very likely stemmed partly from viewing the 3G auction in a different, and narrower, context than Mannesman did.

Just as previous auctions within any country might have been an important part of the wider context, auctions in other countries are also relevant parts of the broader environment: the sequencing of the 3G auctions across countries was crucial. Countries that auctioned earlier had more entrants, because weaker bidders had not yet worked out that they were weaker and quit the auctions, because stronger bidders had not yet worked out how and with whom to do joint ventures, and because complementarities between the values of licenses in different countries reinforced these effects—the number of entrants in the nine western European auctions were (in order) 13, 6, 7, 6, 6, 4, 3, 3, and 5 respectively.[56] Countries that auctioned earlier also suffered less from "collusive" behavior, because bidders had had less practice in learning how best to play the game. For example, when the Austrian 3G auction followed the German 3G auction that we have just described, using almost the same design, all the bidders very quickly saw the mutual advantage of coordinating a demand reduction (see section 4.3.2).[57]

The UK government's advisers anticipated this pattern of declining competition, and chose to run its auction first; indeed we persisted in the policy of running the first auction even when others were advising us to delay. Yet in more than one country auction theorists advising on 3G auction design seemed either unaware of (!), or at least unaffected in their thinking by, the fact that

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[55] In particular, the firms might have been concerned about their relative performances (see also Grimm, Riedel, and Wolfstetter, 2002; Jehiel and Moldovanu, 2002; Ewerhart and Moldovanu, 2002).

[56] Furthermore, the number (6) achieved in the second auction (Netherlands) was perhaps lowered by the peculiarly incompetent design; the number (5) achieved in the last auction (Denmark) was raised by its design, which was very skillful except in its timing (see section 4.3.1). Of course, other factors, in particular the fall in the telecoms stock price index, may have contributed to the fall in the number of entrants.

[57] Chapter 5 develops the arguments in this paragraph in much more detail.

there was to be a sequence of auctions across Europe. Clearly these designers had far too narrow a view of the problem.[58]

Of course, other auctions are only the most obvious aspects of the wider context that auction designers need to consider. There are many other ways in which designers showed themselves very poor at thinking about the wider game. For example, many of the 3G auction designers had a very limited understanding of how the auction process affected, and was affected by, the series of telecom mergers and alliances that the advent of 3G engendered—in the United Kingdom alone, there were no fewer than *five* mergers involving the four incumbent 2G operators, in less than a year around the auction.[59]

## 4.6 Using Economic Theory

I have argued that while a good understanding of elementary undergraduate economic theory is essential to successful auction design, advanced graduate auction theory is often less important. It is important to emphasize, therefore, the crucially important role that advanced formal theory plays in developing our economic understanding. In particular, advanced theory often develops deeper connections between apparently distinct economic questions than are superficially apparent.

For example, chapter 2 demonstrates that auction-theoretic tools provide useful arguments in a broad range of mainstream economic contexts. As a further illustration, I will discuss how a part of the received auction theory— the effect of affiliation—that was, I have argued, not central to the auctions of 3G licenses, can develop useful insights about the economics of the "m-Commerce" industry that 3G will create.[60]

### 4.6.1 Do e-Commerce and m-Commerce Raise Consumer Prices?

Some commentators and regulators have expressed concern that e-commerce and m-commerce ("mobile commerce" in which people purchase through

[58] Some of the incumbent bidders, by contrast, may possibly have had a clearer understanding. In an interesting example of the importance of political pressures, the Dutch operators successfully lobbied to delay the Netherlands auction and the clear gap that was thereby created between the British and Dutch auctions may have been a contributory factor to the Dutch fiasco.

[59] Section 7.3 gives another illustration of how real-world context that was non-obvious to outsiders was important to the UK 3G auction.

[60] Section 2.2 uses the other main piece of the received auction theory—the revenue equivalence theorem—to solve a war of attrition between several technologies competing to become an industry standard in, for example, 3G (see also Bulow and Klemperer, 1999) and to compute the value of new customers to firms when consumers have switching costs as they do for, for example, 3G phones (see also Bulow and Klemperer, 1998). Section 2.3.1 also uses auction theory to address how e-commerce (and likewise m-commerce) affects pricing.

their mobile phones, and which is predicted to expand rapidly as a result of 3G technology) allow firms to easily identify and collect information about their customers which they can use to "rip them off".[61]

A simple analysis realizes that each consumer is analogous to an auctioneer, while firms are bidders competing to sell to that consumer. As we discussed in section 4.2, bidders' expected profits derive from their private information, and the auctioneer generally gains by reducing the amount of bidders' private information. So if all firms learn the same piece of information about a given consumer, this (weakly) reduces the private information that any bidder has relative to the other bidders, and so often benefits the auctioneer, that is, lowers the consumer's expected transaction price.

Although this result is a good start, it is neither very novel,[62] nor does it address the bigger concern that e-and m-commerce allow different firms to learn different information about any given consumer. However, Bulow and Klemperer (forthcoming) show how to use the mathematics of affiliation to address this issue too; in our model, even if firms learn different information about the consumers, this makes the market more competitive. In other words, a quick application of Milgrom and Weber's (1982a) analysis suggests that the "loss of privacy" caused by 3G and the internet is actually *good* for consumers.

Of course, having been cautious about the practical significance of affiliation in auction design, we should also be cautious about asserting that Bulow and Klemperer's argument shows that 3G is not as valuable to firms as some people once thought.[63] However, our model suggests a possibility which needs further study—including considering any empirical evidence and the plausibility of the intuitions—to confirm or disconfirm. Moreover, it certainly demonstrates that just because firms learn more about consumers, it does not follow that they can exploit them better—just as the RET refutes any simple presumption that one form of auction is always the most profitable. Our analysis therefore shows that firms' learning has other effects in addition to the very obvious one that firms can price-discriminate more effectively, and it helps us to see what these effects are[64]—we can then consider further whether these effects are plausibly significant. It also provides a structure which suggests

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[61] The US Federal Trade Commission has held hearings on this issue, and the European Commission is currently studying it. Amazon has admitted charging different prices to different consumers.

[62] Thisse and Vives (1988), Ulph and Vulkan (2001), and Esteves (forthcoming), for example, have developed similar results.

[63] Of course, there are more important reasons why 3G is no longer thought as valuable as it once was (see section 5.5).

[64] In this case, while a firm may raise prices against consumers who particularly value its product, in a competitive environment it will also lower prices to other consumers who like it less—and other firms will then have to respond.

what other factors not in the simplest model might in fact be important, and might perhaps yield the originally hypothesized result.[65] And it very quickly and efficiently yields results that provide a good starting point for such further analysis.

Bulow and Klemperer pursue these issues in the context of this specific application. Chapter 2 considers a range of other applications, including some that at first glance seem quite distant from auctions. The moral is that the "received auction theory" *is* of great value in developing our understanding of practical issues. But it needs to be used in conjunction with developing intuition and gathering empirical evidence to check its applicability to specific situations.


4.7 CONCLUSION

This chapter is *not* attacking the value of economic theory. I have argued that elementary economic theory is essential to successful economic policy. Furthermore, the methods of thinking that undergraduate economics teaches are very valuable, for example, in understanding the important distinction between Hong Kong's two superficially similar auction designs (the one proposed and the one actually implemented). I have focused on examples from auctions, but the more I have been involved in public policy (for example, as a UK Competition Commissioner), the more I have been impressed by the importance of elementary undergraduate economics.

Nor is this chapter intended as an attack on modern, or sophisticated, or graduate economics. True, the emphasis of some graduate courses is misleading, and the relative importance of different parts of the theory is not always well understood, but almost all of it is useful when appropriately applied; it is *not* true that all economic problems can be tackled using undergraduate economics alone.[66]

Policy errors are also less likely when expertise is not too narrowly focused in one subdiscipline—for example, auction designers should remember their industrial economics and political economy (at least) in addition to pure auction theory.

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[65] For example, the analysis shows that even though it may be no bad thing for consumers if different firms learn different pieces of information about them, the result depends on firms learning the same amount of information about any given consumer. It probably is costly for a consumer to "lose his privacy" to only one firm, just as having asymmetrically informed bidders may be a bad thing for an auctioneer. Furthermore, even when firms learn the same amount of information about consumers' tastes, this information may sometimes lead to inefficient price-discrimination which reduces total welfare, in which case consumers may be made worse off even though firms' profits are lowered, just as inefficient auctions may be bad for both auctioneers and bidders. Learning information may also affect firms' abilities to collude, and the ease of new entry.

[66] Furthermore, it is often only the process of thinking through the sophisticated graduate theory that puts the elementary undergraduate theory in proper perspective.

While advanced theory can be misapplied, the correct answer is not to shy away from it, but rather to develop it further to bring in the important issues that have been omitted. It may sometimes be true that "a little bit too much economics is a dangerous thing", but it is surely also true that a great deal of economic knowledge is best of all. Moreover auction theory also illustrates that when a subdiscipline of economics becomes more widely used in practical policy making, its development becomes more heavily influenced by the practical problems that really matter. Like a rapidly growing bush, theory may sometimes sprout and develop in unhelpful directions, but when pruned with the shears of practical experience it will quickly bear fruit!

Furthermore, advanced economic theory is of practical importance in developing our economic understanding of the world, even when it cannot be directly applied to an immediate practical problem. To recapitulate only the incomplete list of its merits that was illustrated by our example in section 4.6, it refutes over-simple arguments, makes precise and quantifies other arguments, allows us to see the relationship between superficially unconnected problems, organizes our ideas, brings out the important features of problems, shows possibilities, and quickly develops general results which, even when they are not final answers, provide good starting points for further analysis.

Nevertheless, the main lesson of this chapter is that the blinkered use of economic theory can be dangerous. Policy advisers need to learn from Marshall's example to beware of the wider context, anticipate political pressures, and, above all, remember that the most sophisticated theory may not be the most relevant.