

Partial List of the Economics Literature Related to FCC Auctions*

(Abstracts provided where available)

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1. Afualo, Valeen and John McMillan (1998), “Auctions of Rights to Public Property,” in *The New Palgrave Dictionary of Economics and the Law*, Vol.1, ed. Peter Newman, London: Macmillan and New York: Grove’s Dictionaries, 125-129.

Auctions are used by governments for a variety of purposes. Government debt is managed in many countries by the auctioning of government securities. Foreign-exchange auctions are run by many governments, including Jamaica, Bolivia, Nigeria, and Romania. Reforming governments, from the Czech Republic to Mexico, have used auctions to privatize state-owned firms. Developing countries use auctions in franchising infrastructure projects to private firms, in sectors such as water, telecommunications, transport, waste disposal, and power. Governments occasionally use auctions to implement policy: for example, in the 1980s the governments of New Zealand and Australia auctioned import quotas as part of a process of trade liberalization, and in 1993 the government of Russia began auctioning licenses for exports and imports.

2. Ausubel, Lawrence M., Peter Cramton, R. Preston McAfee, and John McMillan (1997), “Synergies in Wireless Telephony: Evidence from the Broadband PCS Auctions,” *Journal of Economics & Management Strategy*, 6(3), 497–527.

We examine bid data from the first two broadband PCS spectrum auctions for evidence of value synergies. First, we estimate a benchmark regression for the

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determinants of final auction prices. Then, we include variables reflecting the extent to which bidders ultimately won or already owned the adjacent wireless properties. Consistent with geographic synergies in an ascending-bid auction, prices were higher when the highest losing bidder had adjacent licenses. The footprints of winning bidders suggest that they were often successful in realizing these synergies.

3. Banks, Jeffrey, Mark Olson, David Porter, Stephen Rassenti, and Vernon Smith (2003), “Theory, Experiment and the Federal Communications Commission Spectrum Auctions,” *Journal of Economic Behavior and Organization* 51, 303–350.
4. Binmore, Kenneth, and Paul Klemperer (2002), “The Biggest Auction Ever: The Sale of the British 3G Telecom Licences,” *The Economic Journal* 112(478), C74-C96(23).

This paper reviews the part played by economists in organising the British third-generation mobile-phone licence auction that concluded on 27 April 2000. It raised £22½ billion (\$34 billion or 2½% of GNP) and was widely described at the time as the biggest auction ever. We discuss the merits of auctions versus ‘beauty contests’, the aims of the auction, the problems we faced, the auction designs we considered, and the mistakes that were made.

5. Brusco, Sandro and Giuseppe Lopomo (2002), “Collusion Via Signaling in Simultaneous Ascending Bid Auctions With Multiple Objects and Complementarities,” *The Review of Economic Studies* 69(2), 407–436.

Collusive equilibria exist in simultaneous ascending bid auctions with multiple objects, even with large complementarities in the buyers’ utility functions. The bidders collude by dividing the objects among themselves, while keeping the prices low. In the most collusive equilibrium the complementarities are never realized. The scope for collusion however narrows as the ratio between the number of bidders and the number of objects increases.

6. Bykowsky, Mark M., Robert J. Cull, and John O. Ledyard (2000), “Mutually Destructive Bidding: The FCC Auction Design Problem,” *Journal of Regulatory Economics* 17(3), 205–228.

In general, synergies across license valuations complicate the auction design process. Theory suggests that a simple (i.e., non-combinatorial) auction will have difficulty in assigning licenses efficiently in such an environment. This difficulty increases with increases in fitting complexity. In some environments, bidding may become mutually destructive. Experiments indicate that a properly designed combinatorial auction is superior to a simple auction in terms of economic efficiency and revenue generation in bidding environments with a low amount of fitting complexity. Concerns that a combinatorial auction will cause a threshold problem are not borne out when bidders for small packages can communicate.

7. Chakravorti, Bhaskar, William W. Sharkey, Yossef Spiegel, and Simon Wilkie (1995), "Auctioning the Airwaves: The Contest for Broadband PCS Spectrum," *Journal of Economics and Management Strategy* 4(2), 345–374.

The House and Senate of the United States Congress recently passed legislation that directs the FCC to establish a system for using auctions to allocate the use of radio spectrum for personal communications services. There is a unique and unprecedented set of issues that arise in this context, which are of interest to economists, industry analysts, regulators, and policymakers. We discuss these issues and evaluate their likely impact on the outcome of the spectrum auctions. In addition, we argue that there may be pitfalls in the auction procedure adopted by the FCC, and we discuss possible alternative procedures.

8. Cramton, Peter (1995), "Money Out of Thin Air: The Nationwide Narrowband PCS Auction," *Journal of Economics and Management Strategy* 4(2), 267–344.

The Federal Communications Commission held its first auction of radio spectrum at the Nationwide Narrowband PCS Auction in July 1994. The simultaneous multiple-round auction, which lasted five days, was an ascending bid auction in which all licenses were offered simultaneously. This paper describes the auction rules and how bidders prepared for the auction. The full history of bidding is presented. Several questions for auction theory are discussed. In the end, the government collected \$617 million for ten licenses. The auction was viewed by all as a huge success—an excellent example of bringing economic theory to bear on practical problems of allocating scarce resources.

9. Cramton, Peter (1998), “The Efficiency of the FCC Spectrum Auctions,” *Journal of Law and Economics* 41, 727–736.

From July 1994 to July 1996, the Federal Communications Commission (FCC) conducted nine spectrum auctions, raising about \$20 billion for the U.S. Treasury. The auctions assigned thousands of licenses to hundreds of firms. Were the auctions efficient? Did they award the licenses to the firms best able to turn the spectrum into valuable services for consumers? There is substantial evidence that the FCC’s simultaneous ascending auction worked well. It raised large revenues. It revealed critical information in the process of bidding and gave bidders the flexibility to adjust strategies in response to new information. As a result, similar licenses sold for similar prices, and bidders were able to piece together sensible sets of licenses.

10. Cramton, Peter (1997), “The FCC Spectrum Auctions: An Early Assessment,” *Journal of Economics and Management Strategy* 6(3), 431–495.

This paper analyzes six spectrum auctions conducted by the Federal Communications Commission (FCC) from July 1994 to May 1996. These auctions were simultaneous multipleround auctions in which collections of licenses were auctioned simultaneously. This auction form proved remarkably successful. Similar items sold for similar prices and bidders successfully formed efficient aggregations of licenses. Bidding behavior differed substantially in the auctions. The extent of bidder competition and price uncertainty played an important role in determining behavior. Bidding credits and installment payments also played a major role in several of the auctions.

11. Cramton, Peter and Jesse A. Schwartz (2002), “Collusive Bidding in the FCC Spectrum Auctions,” *Contributions to Economic Analysis and Policy* 1(1).

This paper describes the bid signaling that occurred in many of the FCC spectrum auctions. Bidders in these auctions bid on numerous spectrum licenses simultaneously, with bidding remaining open on all licenses until no bidder is willing to raise the bid on any license. Simultaneous open bidding allows bidders to send messages to their rivals, telling them on which licenses to bid and which to avoid. This “code bidding” occurs when one bidder tags the last few digits of its bid with the market number of a related license. We examine how

extensively bidders signaled each other with retaliating bids and code bids in the DEF-block PCS spectrum auction. We find that only a small fraction of the bidders commonly used retaliating bids and code bids. These bidders won more than 40% of the spectrum for sale and paid significantly less for their overall winnings.

12. Cramton, Peter and Jesse A. Schwartz (2000), “Collusive Bidding: Lessons from the FCC Spectrum Auctions,” *Journal of Regulatory Economics* 17, 229–252.

The Federal Communications Commission (FCC) spectrum auctions use a simultaneous ascending auction design. Bidders bid on numerous communication licenses simultaneously, with bidding remaining open on all licenses until no bidder is willing to bid higher on any license. With full revelation of bidding information, simultaneous open bidding allows bidders to send messages to their rivals, telling them on which licenses to bid and which to avoid. These strategies can help bidders coordinate a division of the licenses, and enforce the proposed division by directed punishments. We examine solutions to mitigate collusive bidding in the spectrum auctions, and then apply these ideas to the design of daily electricity auctions.

13. Cramton, Peter, Yoav Shoham, and Richard Steinberg (2006), *Combinatorial Auctions*, Cambridge, MA: MIT Press.

14. Grimm, Veronika, Frank Riedel, and Elmar Wolfstetter (2001), “Low Price Equilibrium in Multi-Unit Auctions: The GSM Spectrum Auction in Germany,” Working Paper, Humboldt Universität zu Berlin.

The second-generation GSM spectrum auction in Germany is probably the most clear cut example of a low price outcome in a simultaneous ascending-bid auction. The present paper gives an account of the events, describes the auction rules and market conditions, and provides a theoretical explanation of low price equilibria in simultaneous, ascending-bid auctions. In particular it is shown that the low price equilibrium that implements the efficient allocation is the unique perfect equilibrium of that game.

15. Hazlett, Thomas W. (1998), “Assigning Property Rights to Radio Spectrum Users: Why Did FCC License Auctions Take 67 Years?,” *Journal of Law and Economics* 41, 529–575.

While Leo Herzel (1951) and Ronald Coase (1959) persuasively argued for auctioning licenses issued by the Federal Communications Commission (FCC), not until 1993 did the U.S. Congress grant the FCC authority to assign wireless operating permits via competitive bidding. Why were auctions, with obvious efficiency and equity advantages, so long in coming? Why were comparative hearings in the “public interest” first abandoned as assignment tools in 1981 not for auctions, but for lotteries? And why were radio and TV licenses pointedly excluded from auctions? Four factors—the special interest of regulators in influencing broadcasting content, the limits placed on explicit program regulation by the U.S. Constitution, the recent increase in the relative economic importance of nonbroadcast wireless services, and the agency problem embedded in central planning—are used to explain both the political stability of economically inefficient licensing methods and recent reforms.

16. Illing, Gerhard and Ulrich Klüh (2003), *Spectrum Auctions and Competition in Telecommunications* (CESifo Seminar Series), Cambridge, MA: MIT Press.
17. Jehiel, Phillipe and Benny Moldovanu (2001), “The UMTS/IMT-2000 License Auctions.” Working Paper, University College London and University of Mannheim.

We survey the recent European UMTS license auctions and compare their outcomes with the predictions of a simple model that emphasizes future market structure as a main determinant of valuations for licenses. Since the main goal of most spectrum allocation procedures is economic efficiency, and since consumers (who are affected by the ensuing market structure) do not participate at the auction stage, good designs must alleviate the asymmetry among incumbents and potential entrants by actively encouraging entry.

18. Klemperer, Paul (2002), “What Really Matters in Auction Design,” *Journal of Economic Perspectives* 16(1), 169–189.

The most important issues in auction design are the traditional concerns of competition policy—preventing collusive, predatory, and entry-detering 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. (Abstract taken from the working paper version)

19. Klemperer, Paul *Auctions: Theory and Practice* (The Toulouse Lectures in Economics).
20. Krishna, Vijay (2002), *Auction Theory*, London: Academic Press.
21. Kwasnica, Anthony M. and Katerina Sherstyuk (2001), “Collusion via Signaling in Multiple Object Auctions with Complementarities: An Experimental Test,” Working Paper.

We experimentally study bidder collusion in open ascending auctions for multiple objects. The project is based on the theoretical results by Brusco and Lopomo (1999), who give theoretical support for the following claims: (1) simultaneous ascending bid auctions can be vulnerable to collusion in the multi-object case; (2) The sole presence of complementarities does not hinder collusion; (3) Collusion is a “low numbers” phenomenon. We focus on a simultaneous ascending auction for two objects. Several experimental treatments are considered: markets with low numbers (2 bidders) and high numbers (5 bidders), no complementarities (additive values) and complementarities (superadditive values). Experimental results are largely consistent with the theory. Collusion is often observed in two-person markets with or without complementarities. Previous experience under the same treatment greatly facilitates bidder collusion. There is no evidence of collusion in five-person markets. We further study collusive strategies adopted by bidders in two-person markets. While most strategies make extensive use of signaling, in the presence of complementarities, bidders use collusive strategies that are supported only by repeated play.

22. Kwerel, Evan R. and Gregory L. Rosston (2000), “An Insiders’ View of FCC Spectrum Auctions,” *Journal of Regulatory Economics* 17(3), 253–289.

After a long period of awarding spectrum licenses inefficiently, changes in the budget and budgetary process coupled with increases in the value of the spectrum for non-broadcast use led Congress to allow the Federal Communications Commission to award licenses through competitive bidding. Contrary to the perceived view of government bureaucracies as excessively cautious, the FCC used the newfound authority to adopt a novel approach to auction design—simultaneous multiple round auctions. The innovative auction design would not have been adopted without the successful collaboration between government economists and academic economists, who helped to formulate and refine the design so that decision makers at the FCC could be convinced that the novel technique was both superior and practical. The FCC’s implementation of competitive bidding was not only rapid as mandated by Congress, but also much less costly than outside alternatives and allowed the integration of spectrum policy decisions and auction design. Experience from several auctions has led to a number of open questions and refinements. The FCC is trying to replicate the success with the original auction design by facilitating dialog between the agency and outside auction experts in order to address these issues.

23. Ledyard, John O., David Porter, and Antonio Rangel (1997), “Experiments Testing Multiobject Allocation Mechanisms,” *Journal of Economics & Management Strategy* 6(3), 639–675.

This paper reports the results of over 130 auctions conducted under controlled conditions to examine the robustness of several auction mechanisms to allocate multiple objects. The simultaneous discrete auction process used by the Federal Communications Commission to allocate Personal Communications licenses was contrasted with a sequential auction and a combinatorial auction over a variety of demand conditions. In test environments created to check only the minimum competency of the procedures, the simultaneous discrete auction process produces highly efficient allocations, approaching levels similar to those found with a continuous form of the auction, and it outperforms a sequential auction. However, in environments created to stress test the procedures, a combinatorial auction outperforms the simultaneous discrete auction.

24. Marshall, Robert C. and Leslie M. Marx (2007), “Bidder Collusion,” *Journal of Economic Theory* 133, 374–402.

We analyze bidder collusion at first-price and second-price auctions. Our focus is on less than all-inclusive cartels and collusive mechanisms that do not rely on auction outcomes. We show that cartels that cannot control the bids of their members can eliminate all ring competition at second-price auctions, but not at first-price auctions. At first-price auctions, when the cartel cannot control members' bids, cartel behavior involves multiple cartel bids. Cartels that can control bids of their members can suppress all ring competition at both second-price and first-price auctions; however, shill bidding reduces the profitability of collusion at first-price auctions.

25. McAfee, R. Preston and John McMillan (1996), "Analyzing the Airwaves Auctions," *Journal of Economic Perspectives* 10(1), 159–175.

The US government recently sold spectrum rights using an innovative auction design, the simultaneous ascending auction, invented by economic theorists. The auction outcomes were broadly consistent with the expectations of the theorists. The auction form should have many other applications. (Abstract taken from the working paper version)

26. McAfee, R. Preston and John McMillan (1987), "Auctions and Bidding," *Journal of Economic Literature* 25, 699–738.
27. McMillan, John (1995), "Why Auction the Spectrum?," *Telecommunications Policy* 19, 191-199.

Of the alternative spectrum-allocation methods—administrative process, lottery, first come first served, and auction—economic theory, as well as various countries' experiences, show that auctioning works best. As well as raising revenue, an auction assigns licenses to the firms best able to use them. Also, the auction can be designed to advance public-policy goals such as avoiding monopoly and directing licenses to minority-owned firms.

28. McMillan, John (1994), "Selling Spectrum Rights," *Journal of Economic Perspectives* 8(3), 145–162.

The design of the FCC spectrum-license auction is a case study in the application of economic theory. Auction theory helped address policy questions such as: Should an open auction or a sealed-bid auction be used? Should the licenses

be auctioned sequentially or simultaneously? Should the government allow bids for combinations of licenses, or should it accept only single-license bids? How should the auction be structured to promote the interests of minority-owned and other designated firms? Should the government impose royalties or reserve prices? How much should the bidders be informed about their competition? (Abstract taken from the working paper version)

29. Milgrom, Paul (2004), *Putting Auction Theory to Work*, Cambridge, UK: Cambridge University Press.
30. Plott, Charles R. (1997), "Laboratory Experimental Testbeds: Application to the PCS Auction," *Journal of Economics & Management Strategy* 6(3), 605–638.

The paper reviews the uses of laboratory experimental economics methods in the background research and implementation of the Personal Communication Systems auctions held by the Federal Communications Commission. The applications began during the rule making process with the testing of broad rules that might be implemented. Data from experiments were systematically used. The methods were used again in the software development process where several important contributions were made. Finally, experiences gained from the study of experimental auction processes were used in the actual management of the first auctions and in interpreting auction performance.

31. Salant, David J. (1997), "Up in the Air: GTE's Experience in the MTA Auction for Personal Communication Services Licenses," *Journal of Economics & Management Strategy* 6(3), 549–572.
32. Stuewe, Heinz (1999), "Auktion von Telefonfrequenzen: Spannung bis zur letzten Minute," *Frankfurter Allgemeine Zeitung*, October 29.
33. Weber, Robert J. (1997), "Making More From Less: Strategic Demand Reduction in the FCC Spectrum Auctions," *Journal of Economics & Management Strategy* 6(3), 529–548.

When multiple items are sold through the use of simultaneous ascending-bid auctions, bidders can find it in their mutual interests to reduce their aggregate

demand for the items while prices are still low relative to the bidders' valuations. The FCC's first broadband PCS auction provides examples of how such mutual reductions might be arranged even when the bidders are not allowed to communicate with one another outside of the auction arena.