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Allocating Spectrum through the Use of Auctions

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Introduction

Recent proposals brought forth by the Bush Administration advocate the allocation of spectrum through the use of auctions.[1] Although supporters of these plans frequently point to the potential revenue that could be generated by this mechanism, auctions have long been recognized in economics as an efficient means of allocating resources.[2] Besides allowing a seller to determine the true value of a sale item, a well-crafted auction also awards the contested object to the bidder who values it the most. Thus, an auction simulates the competitive market.

This article provides an overview of auction theory and suggests an auction mechanism for the allocation of spectrum. Although auctions can be effective vehicles for distributing resources, the potential modification of various auction rules could disadvantage participants in any future bidding process. For example, rules could be imposed that prevent a firm from winning a spectrum auction even when economic theory states that the firm should be the winning bidder. Conversely, an auction could be structured so as to reduce the revenue received by the government from the sale of spectrum. This article will therefore only focus on a bidding mechanism that does not disadvantage either the seller (*i.e.*, the federal government) or the buyer in a spectrum auction.

This article begins with a brief discussion of the theory behind auctions and why this mechanism has been advocated for spectrum allocation, followed by a description of the four primary types of auctions. Theoretical and empirical evidence will be used to show how economic efficiency is influenced by these different auction procedures. This article then discusses the risks associated with auctions and concludes with a recommended auction format for the allocation of spectrum.

1. ECONOMIC REPORT OF THE PRESIDENT 146 (1991); U.S. DEPT. OF COMMERCE, U.S. SPECTRUM MANAGEMENT POLICY: AGENDA FOR THE FUTURE 114 (1991).

2. It should also be noted that auctions have also been advocated for other lines of business in which communications companies may want to participate in the future. Harold Demsetz, for example, has proposed that firms compete in an auction to provide a monopoly service. Harold Demsetz, *Why Regulate Utilities?* 11 J. L. & ECON. 55, 58 (1968). The winner (i.e., the one with the lowest charge to customers) would not have to be rate of return regulated. *Id.* Similarly, auctions have also been used or proposed for cable television and cellular telephone service. *See generally,* Michael A. Crew & Mark A. Zupan, *Franchise Bidding for Public Utilities Revisited, in* COMPETITION AND THE REGULATION OF UTILITIES 173 (Michael A. Crew ed., 1990); Evan Kwerel & Alex D. Felker, Using Auctions to Select FCC Licensees (Federal Communications Commission, OPP Working Paper No. 16, 1985); Mark A. Zupan, *The Efficacy of Franchise Bidding Schemes in the Case of Cable Television: Some Systematic Evidence,* 32 J. L. & ECON. 401 (1989). *But see generally,* Oliver E. Williamson, *Franchise Bidding for Natural Monopolies—in General and with Respect to CATV,* 7 BELL J. ECON. 73 (1976).

I
Auction Theory and the Allocation of Spectrum

The first reported use of auctions occurred during the 6th century B.C. when the Babylonians annually sold women of marriageable age on condition that they wed.[3] Since that time, auctions have been used for such varied purposes as contracting for interstate highway construction,[4] selling used airplanes,[5] and marketing rare art.[6] Although these examples would appear to have little in common, the key attributes of these auction sales are that competition occurs on only one side of the market and pricing information is limited.

Unlike a competitive market, auctions are characterized by an environment where either buyers vie for the right to purchase a good from one vendor or sellers compete to sell their products to one purchaser. For example, the seller of a used car may know how much he previously paid for the car, but may not know what price this object would command in the current market. Even though this vendor could sell his car to the first person who offered him money, the seller could never be sure if this was the highest price he could have received from a sale. By setting up a system in which all the potential buyers are allowed to compete for the car, an auction reveals the market price to the seller.

An auction for this car also leads to the most efficient use of this item. If a used car was sold to someone who bid less than the auction price and the car was then broken up for scrap, society might be worse off than if another person made a higher payment and used this car for travel. By transferring the used car to the individual who values it the most, an auction guarantees that society's resources are used efficiently.

As with the sale of used cars, most economists prefer auctions over the current system of spectrum management.[7] Because users are not forced to bear a direct cost for their spectrum allocation, the present pro-

3. RALPH CASSADY, JR., AUCTIONS AND AUCTIONEERING 26 (1967).

4. Stuart C. Thiel, *Some Evidence on the Winner's Curse*, 78 AM. ECON. REV. 884, 888-89 (1988).

5. CASSADY, *supra* note 3, at 17.

6. *See generally* Jorge Contreras, *The Art Auctioneer: Duties and Assumptions*, 13 HASTINGS COMM/ENT L.J. 717 (1991). Auctions have even been used to determine who would be emperor of Rome. After killing Pertinax in 193 A.D., the Praetorian Guard sold the crown of the Roman Empire to the person who bid the most in auction. Didius Julianus, who paid each man of the Guard 6,250 drachmas, lasted as emperor for only two months before he was overthrown and killed by Septimius Severus. This is another example of the truth in the statement, "Caveat Emptor." CASSADY, *supra* note 3, at 29.

7. For example, see R.H. Coase, *The Federal Communications Commission*, 2 J. L. & ECON. 1, 17 (1959); Arthur S. De Vany et al., *A Property System for Market Allocation of the Electromagnetic Spectrum: A Legal-Economic-Engineering Study*, 21 STAN. L. REV. 1499, 1529 (1969); Kwerel & Felker, *supra* note 2, at 26.

cedure of spectrum management may not promote an efficient use of society's resources. Allocative efficiency could be enhanced using an auction because prices bid for spectrum would reflect the cost to society for use of that resource. Rather than being zero, the cost of spectrum from an auction may more clearly represent the opportunity cost of providing a radio-based service in the market.

The idea of selling spectrum to potential users was first proposed in 1969.[8] Besides advocating the use of auctions to sell spectrum, Arthur De Vany *et al.* proposed that portions of radio frequency be purchased on a time, area, and spectrum (TAS) basis.[9] A buyer of spectrum under the TAS system would not only have the right to use his allotted spectrum during a given time of day within a specified area, but would also be allowed to negotiate with other TAS owners to alter the specifications of his allocation if necessary.[10] Under this system, transaction and enforcement costs could be reduced and social welfare could be increased. After setting up the initial auction, the FCC could play a largely passive role as market forces would regulate spectrum.

Although the TAS concept has not been formally embraced by the FCC, the allocation of spectrum through the use of auctions has gained support by various groups within the government.[11] As noted by Kwerel and Felker, spectrum auctions are superior to lotteries and comparative hearings in terms of cost and processing time.[12] An auction typically costs only fifteen percent of the expense of either hearings or lotteries.[13] Processing time for an auction is three months as compared to twelve months for a lottery and eighteen months for a comparative hearing.[14] Thus, Kwerel and Felker concluded that auctions reduce the indirect costs associated with the current system of spectrum management.[15]

Unlike the United States, New Zealand has already embraced the idea of using auctions to allocate spectrum.[16] The New Zealand Ministry of Commerce recently held auctions to award the rights for the 'A' block

8. De Vany et al., *supra* note 7, at 1559; *see also,* Douglas W. Webbink, *Radio Licenses and Frequency Spectrum Use Property Rights,* COMM. L., June 1987, at 3-4, 25-26.

9. De Vany et al., *supra* note 7, at 1512.

10. *Id.* at 1512-18.

11. Kwerel & Felker, *supra* note 2, at 21.

12. *Id.* at 17.

13. *Id.* at 20.

14. *Id.* at 17.

15. *Id.* at 19. *But see,* Severin Borenstein, *On the Efficiency of Competitive Markets for Operating Licenses,* 103 Q. J. ECON. 357, 382 (1988).

16. For further details on this process in New Zealand, see Kuehl, *New Zealand Reeling in Profits from Auction of Cellular Spectrum,* RADIO COMM. REP., at 1; NEW ZEALAND MINISTRY OF COMMERCE & NERA, MANAGEMENT OF THE RADIO FREQUENCY SPECTRUM IN NEW ZEALAND (1988); Bruce Slane, *Trading in the Radio Spectrum: A New Management Rights Approach,* N. Z. L. J. 396 (1989).

American Mobile Phone Standard (AMPS) and both the 'A' and 'B' blocks of the Total Access Communications Standard (TACS).[17] This bidding process, which yielded an estimated NZ$20 million (or $11.9 million in current U.S. dollars) for the New Zealand Government,[18] is now being considered by Australia, Canada, and the United Kingdom.[19] This move by other countries to a market-based system for spectrum management may ultimately disadvantage the U.S. in future competition.

II
Types of Auctions

Auctions are classified according to the set of rules governing the exchange. These rules not only determine the ultimate price bid in the auction, but also establish the final resource allocation. Since the landmark paper by William Vickrey,[20] auctions have been broken down into four basic types.[21]

A. English

This auction (also called the oral, open, or ascending-bid auction) is the bidding form most commonly used for selling goods.[22] In the English auction, each bidder states his price until only one bidder remains.[23] When no bidder chooses to further increase his bid, the highest bidder wins and pays the bid amount.[24]

The significant feature of this type of auction is that each competitor knows the current high bid and can judge whether or not to continue in the auction. In order to be successful in this type of auction, a contestant must construct a strategy involving the firm's bids as a function of its own valuation of the good, its prior estimate of other firms' valuation, and the past bids of all the other firms.[25] An English auction requires a bidder to anticipate his competitors' actions.

17. Kuehl, *supra* note 16, at 1.

18. U.S. DEPARTMENT OF COMMERCE, U.S. SPECTRUM MANAGEMENT POLICY: AGENDA FOR THE FUTURE, 95 n.316 (1991).

19. *Id.*

20. William Vickrey, *Counterspeculation, Auctions, and Competitive Sealed Tenders*, 16 J. FIN. 8 (1961).

21. For more detail on the following types of auctions, see generally R. Preston McAfee & John McMillan, *Auctions and Bidding*, 25 J. ECON. LIT. 699 (1987); Paul Milgrom, *Auctions and Bidding: A Primer*, J. ECON. PERSP., Summer 1989, at 3.

22. McAfee & McMillan, *supra* note 21, at 702.

23. ERIC RASMUSEN, GAMES AND INFORMATION: AN INTRODUCTION TO GAME THEORY 247 (1989).

24. *Id.*

25. *Id.*

B. Dutch

The Dutch auction is the converse of the English auction. In this auction the seller announces a bid, which she continuously lowers until some buyer stops her and takes the object being bid on at that price.[26] This type of auction, though rare in the United States, is used for selling cut flowers in the Netherlands, fresh fish in Israel, and tobacco in Canada.[27]

The bidder in this type of auction follows a simple strategy involving her valuation and her estimates of what the other competitors would bid. A bidder attempts to maximize her benefit by stopping the bidding at a price which is below her valuation but above the estimated price any one of her rivals would select. If a bidder misjudges her rivals' bids, then this contestant may lose the auction even though she may value the item the most.

C. Sealed Bid

In the sealed bid (also known as the first-price sealed bid) auction, each bidder submits one bid, in ignorance of the other bids, and the highest bidder pays the winning amount.[28] Because a participant is allowed to make only one bid, a competitor's strategy is highly dependent on the firm's own valuation of the contested item and its prior beliefs about other firms' valuations.[29] A successful bid in this type of auction will be enhanced by expending resources to estimate all of the contestants' valuations of the good.

This type of auction, which has been used by the Federal government for the sale of offshore mineral rights and procurement contracts,[30] is cited as a defense against collusion.[31] Although Isaac and Walker have found that a sealed bid auction can foster a "bid-rigging" cartel, collusion among competitors can easily be thwarted by only one non-cooperating bidder.[32] Furthermore, by not announcing what any of the competitors bid in a sealed bid auction, the possibility of collusion is further reduced.[33] Members of the cartel cannot be sure if all the partici-

26. *Id.* at 249-50.

27. McAfee & McMillan, *supra* note 21, at 702.

28. RASMUSEN, *supra* note 23, at 247-48.

29. *Id.* at 247.

30. *See generally,* Walter J. Mead et al., *Competition in Outer Shelf Oil and Gas Lease Auctions: A Statistical Analysis of Winning Bids,* 26 NAT. RESOURCES J. 95 (1986).

31. R. Mark Isaac & James M. Walker, *Information and Conspiracy in Sealed Bid Auctions,* 6 J. ECON. BEHAV. & ORGANIZATION 139, 151-52 (1985).

32. *Id.*

33. McAfee & McMillan, *supra* note 21, at 725. *But see* Issac & Walker, *supra* note 31, at 152.

pants in the bidding ring actually bid their predetermined price. Finally, it has been demonstrated empirically that a sealed-bid auction generates the same amount of revenue to the seller as an open auction.[34]

This auction mechanism is strategically equivalent to the Dutch auction because the same strategy is employed for each of these types of auctions. The only choice open to a bidder in either of these auctions is to determine the highest price he is willing to pay to win the contested good and what is the top bid that he expects any of his rivals to offer. Because both of these auction forms employ the same strategy, the winner and the winning price should always be the same in either the Dutch or sealed bid auctions.

D. Sealed Second-Bid

In 1961, William Vickrey proposed a new type of auction called the sealed second-bid format (also referred to as a second-price sealed bid or Vickrey auction).[35] In this type of auction, each bidder submits one bid, in ignorance of the other bids.[36] The bids are opened and the highest bidder pays the amount of the second highest bid.[37] The dominant strategy employed in this type of auction is simply to bid one's own valuation of the contested object.[38]

In advocating this type of auction, Vickrey pointed out that in a sealed second-bid auction "[e]ach bidder can confine his efforts and attention to an appraisal of the value the article would have in his own hands, at a considerable saving in mental strain and possibly in out-of-pocket expense."[39] Unlike the other bidding formats in which the bidder has to estimate both his value for the item and how much his competitors will offer for the contested good, a contestant in a second-bid auction only reveals to the auctioneer how much she is willing to spend for the item. A bidder who bids less is more likely to lose the auction, but pays the same price if she does win.[40] Although the winning bidder may have the highest bid (*i.e.*, internal value for the object), the actual price paid by the winning bidder is only equal to the second highest bid.

34. Robert G. Hansen, *Sealed-Bid Versus Open Auctions: The Evidence,* 24 ECON. INQUIRY 125, 136 (1986).

35. Vickrey, *supra* note 20, at 21.

36. RASMUSEN, *supra* note 23, at 249.

37. *Id.*

38. Vickrey, *supra* note 20, at 20.

39. *Id.* at 22.

40. *Id.* at 20; *see supra* subpart II(c).

Besides providing protection from collusion through the use of sealed bids[41] and a reduction in costs associated with bidding (because knowledge of competitors' value for the good are not necessary), this auction mechanism also brings one of the advantages of an open auction in which a price is found that only one competitor is willing to pay. Allocative efficiency and an increase in market information both result from a Vickrey auction in theory.[42] In short, a sealed second-bid auction offers consumer safeguards, cost minimization, and efficient prices.

E. Comparison

One of the key conclusions from Vickrey's analysis is that *all four of these auctions result in the same price on average.*[43] Although Vickrey demonstrated this result using a model based on four simplifying assumptions,[44] the Revenue-Equivalence Theorem does not imply that the outcomes from these four auction forms will always be the same.[45] In an English or sealed second-bid auction the winning price equals the valuation of the bidder with the second highest valuation. On the other hand, the winning bid in the first-price sealed bid and Dutch auctions represents the expectation of the second-highest valuation. Even though the actual and expected second-highest valuations will be the same on average, the winning bid may be different for a specific object. Vickrey's analysis has shown that the type of auction a seller chooses does not matter.

The key to evaluating these auctions is seeing how they compare as various assumptions are relaxed and the model more closely resembles the real world. When bidders are not symmetric (*i.e.,* bidders can be divided into classes), the first-price sealed bid auction yields a different result from the English format.[46] If an auction for spectrum, for example, can divide bidders between incumbents and new entrants, a sealed bid auction will not yield the same price as an English auction. In other words, *a first-price sealed bid auction in this example would yield an inefficient economic outcome.*[47]

41. *But see,* Thomas von Ungern-Sternberg, *Cartel Stability in Sealed Bid Second Price Auctions,* 36 J. INDUS. ECON. 351, 357 (1988).

42. Vickrey, *supra* note 20, at 21-22.

43. *See* McAfee & McMillan, *supra* note 21, at 710.

44. These four assumptions are: (1) the bidders are risk neutral; (2) the bidders have independent private values; (3) the bidders are symmetric (i.e., bidders cannot be divided into groups); and (4) payment is a function of the bids alone. *Id.* at 706.

45. For a simple derivation of this result, see John G. Riley, *Expected Revenue from Open and Sealed Bid Auctions,* J. ECON. PERSP., Summer 1989, at 41, 42-43.

46. McAfee & McMillan, *supra* note 21, at 714.

47. *Id.* at 715.

Likewise, these four types of auctions can be modified so that the final price is not a function of the winning bid. For example, in the government auction of oil rights, the winning bidder not only pays his bid but also returns a royalty based on the amount of oil extracted.[48] In any of these auctions, if the seller charges a fixed royalty rate and calls for bids to purchase the resource, revenue to the seller is increased. In other words, *the use of royalties increases the bidding competition in auctions.*[49]

As with charging a royalty, sellers in these four auctions can also increase their receipts by setting a reserve or minimum price.[50] Many auctions set a reserve price which must be met or exceeded in order to buy the contested object.[51] By establishing a base price which is below the highest valuation but above the second highest assessment, a seller raises the price which must be paid by the successful buyer.

Increases in information also raise the level of competition within any auction.[52] If the government has estimates of the true value of spectrum, for example, a release of this information may raise the final price paid to the Treasury. Because new information tends to raise the value estimates of bidders who would bid low, the price paid in an auction will likely increase when a buyer releases information.

On the other hand, economic theory tells us that risk averse buyers will raise the winning price in the sealed-bid and Dutch auctions.[53] If a buyer is afraid to lose an auction, then the bidder is likely to bid in these auctions his true valuation of an item. If the government in a spectrum auction is faced with potential buyers who must have spectrum, then it would be in the government's interest to use either a sealed-bid or Dutch auction to exploit the bidder's fear of losing.

III
Auction Risks

As can be seen from the preceding section, a seller can craft an auction to maximize his revenues. Although a seller could charge a royalty or assess an entry fee on all bidders, these modifications can only be expected to generate an increase in revenues when various assumptions are

48. Mead et al., *supra* note 30, at 95.

49. McAfee & McMillan, *supra* note 21, at 718.

50. John G. Riley & William F. Samuelson, *Optimal Auctions*, 71 AM. ECON. REV. 381, 389 (1981); McAfee & McMillan, *supra* note 21, at 713.

51. McAfee & McMillan, *supra* note 21, at 713.

52. McAfee & McMillan, *supra* note 18, at 722; Urs Schweizer & Thomas von Ungern-Sternberg, *Sealed Bid Auctions and the Search for Better Information,* 50 ECONOMICA 79, 83 (1983).

53. Riley, *supra* note 45, at 48.

relaxed. In general, simple auction forms are the best mechanism for bidding.

The problem with all auctions, regardless of the form, is the "winner's curse." The winner's curse refers to the incorrect estimation of the value of a good. For example, if bidders are competing in a procurement auction, the winning bidder will be the one who is willing to charge the smallest payment from the firm. If all competitors have the same cost function (including a random error term), then the winning bidder will be the competitor that most severely underestimates the true cost. Stated another way, the winner's curse refers to the successful bidder being the one in an auction who overstates the value of the contested item the most.[54]

In order to make money in a competitive bidding situation (and avoid the winner's curse), a bidder needs to adjust his bid for the incorrect estimation of the contested item's value. Although various empirical studies have shown that the winner's curse has not occurred in bidding for offshore oil rights[55] or highway construction contracts,[56] this phenomenon may occur with a spectrum auction. Because this is a new process for most participants, bidders in a spectrum auction may not know to adjust their bids for the winner's curse.

IV
Proposed Auction Format for Spectrum

As can be seen from the previous sections, auctions may be crafted that disadvantage buyers. If auctions are viewed purely as a revenue-producing mechanism by the government, then rules can be established to maximize the price paid by any spectrum bidder.[57] Besides adopting royalty payments, the federal government could, for example, establish a spectrum auction which includes payments from all bidders for the chance to enter an auction or require losing bidders to pay an amount related to their unsuccessful bids. The government, in this scenario, would be intent on maximizing revenues at the expense of economic efficiency.

54. For further details on the winner's curse, see Milgrom *supra* note 21, at 4-6.

55. Kenneth Hendricks & Robert H. Porter, *An Empirical Study of an Auction with Asymmetric Information*, 78 AM. ECON. REV. 865, 882 (1988); Mead et al., *supra* note 30, at 110. *But see* E.C. Capen et al., *Competitive Bidding in High-Risk Situations*, 23 J. PETROLEUM TECH. 641, 643 (1971).

56. Thiel, *supra* note 4, at 894.

57. McAfee & McMillan, *supra* note 21 at 733 (further discussion on how a seller could craft an auction to maximize revenues); *see also*, Jeremy Bulow & John Roberts, *The Simple Economics of Optimal Auctions*, 97 J. POL. ECON. 1060, 1063 (1989).

In order to counter this possibility, an auction policy based on economics should be adopted. A spectrum auction that does not disadvantage either the buyers or the seller of spectrum would most likely promote economic efficiency and ultimately the nation's competitiveness. An auction should be crafted that results in a minimum amount of bidder preparation, offers protection from collusion, and results in an efficient outcome.

The bidding mechanism that most closely fulfills these specifications is a sealed second-bid auction. Besides providing protection from collusion through the use of sealed bids, a Vickrey auction provides a simple strategy for bidders to follow. Estimates of the other bids are not necessary in this type of auction while economic efficiency is promoted. This type of auction has been criticized due to the possibility sellers will cheat or that buyers will be opposed to full disclosure.[58] However, a Vickrey auction could be effectively implemented by the government if bidders were informed about the proper strategy to use and safeguards that were in place to guard against cheating.

Although a reserve price tends to raise the final auction price, a minimum price may be necessary in a spectrum auction. If there is very little free spectrum in a given frequency range, an auction for spectrum for a new service would require the movement of the existing users to another frequency. The reserve price for a spectrum auction should therefore be the cost of compensating the current users. Any difference between the final price and the reserve could then be returned to the Treasury.

In order to avoid the winner's curse, the government should release as much information to prospective bidders as possible. Even though this will have a similar effect to implementing a reserve price, many prospective bidders in a spectrum auction will be new to an auction and will be unsure on how to value spectrum. Release of government information, such as the reserve price or estimates of its potential revenue generation, will raise bids but will also help to prevent the selection of a poorly informed bidder.

Finally, no firm should be precluded from participating in an auction for spectrum simply because it is alleged to have "deep pockets." This is an argument that is sure to be leveled against the large firms that wish to bid on spectrum. This argument goes as follows: auctions favor the large firms that have sizable cash reserves or other considerable financial resources and disfavor other efficient providers that lack such financial resources. This faulty reasoning may lead to some very inefficient

58. Michael H. Rothkopf et al., *Why Are Vickrey Auctions Rare?*, 98 J. POL. ECON. 94, 101-03 (1990).

policies if it is followed. As long as efficient capital markets are available to participants choosing to bid for spectrum, then the "deep pockets" argument is without merit. Moreover, empirical evidence from auctions for offshore oil leases shows that small firms have been able to bid competitively with large firms.[59] No bidder should be precluded from a spectrum auction simply because it is cash rich or financially healthy, and certainly such participation should not handicap smaller firms that can use existing capital market resources in making bids for spectrum.[60]

V
Conclusion

Although spectrum auctions have been cited by the government as a way to increase general revenues, auctions can provide positive benefits to the economy. Besides allowing a seller to determine the true value of a sale item, well-crafted auctions can also result in the winning bidder being the one who values the contested object the most. Thus, an auction may provide an efficient means of allocating resources.

If a bidding process is mandated for spectrum, the author advocates the adoption of a sealed second-bid auction. Besides providing protection from collusion, this type of auction offers a simple strategy for bidders to follow. Estimates of the other competitors' bids are not necessary with this auction format. Although many firms may oppose bidding for spectrum because they could be paying substantial amounts for a resource which they now control at no cost, a properly constructed spectrum auction could provide positive benefits for the national economy.

59. Mead et al., *supra* note 30, at 110.

60. *But see,* Janine S. Natter, note, *Scarcity of the Airwaves: Allocating and Assigning the Spectrum for High Definition Television (HDTV),* 13 HASTINGS COMM/ENT L.J. 199, 225 (1991) (arguing that allocating the spectrum for HDTV to the highest bidder does not necessarily serve the public interest).