U.S. WIRELESS LICENSE AUCTIONS: 1994-2009

Thomas W. Hazlett[1]

July 14, 2009

Long resisted by policy makers, competitive bidding for U.S. wireless licenses commenced July 25, 1994. Since then, some 85 auctions have been held, 27,484 licenses sold, and $52.6 billion paid to the government. Hailed by regulators and academic economists as a success story, the policy reform has resolved several inefficiencies in license assignments. Yet, new challenges have emerged. Over one-third of winning bids have proven uncollectible. More problematically, spectrum allotments stalled, 1996-2006, as policy makers attempted to withhold bandwidth in order to raise (delayed) auction bids. This reduced wireless competition and deterred 3G technology adoption. In 2007-08, regulators began to "de-liberalize" wireless licenses, mandating business models in order to specify market structure. This policy swings back to traditional regulation, attempting to produce "public interest" outputs by controlling spectrum inputs. At bottom, license auctions expose a fundamental tension between welfare-maximizing frequency allocations and government rent-extraction. With the state property spectrum regime intact, assigning licenses by competitive bidding – transferring rents from licensees, including new entrants, to the fisc -- may ironically exacerbate the under-allocation of radio spectrum.

[1] Prof. of Law & Economics, George Mason University, USA: thazlett@gmu.edu. The author thanks Mitch Calhoun for helpful research assistance.

I. Introduction

On July 25, 1994, the Federal Communications Commission commenced Auction No. 1, selling ten Narrowband Personal Communications Services (N-PCS) licenses used for paging services. Aggregate winning bids of $617 million were generated. While N-PCS failed to prove profitable,[2] the government captured significant revenues and moved to hold additional auctions. In March 1995, 99 broadband personal communications services licenses (PCS) offering rights enabling competition with cellular operators were sold for $7 billion. As of July 1, 2009, the U.S. Government had realized $52.6 billion in license revenues.[3]

Auctions are now a well-established license assignment tool. "[S]pectrum auctions in the US have been a great success,"[4] a viewpoint widely shared by economists.[5] Policy makers have been energetic in claiming credit for their implementation. Indeed, wireless auctions now constitute a paradigmatic example of efficient regulatory reform.

One has to peer into history to discover that the policy was highly contentious. Competitive bidding for licenses was proposed for many decades prior to its congressional authorization in 1993.[6] The legislative change occurred only after other countries – notably New Zealand[7] and India[8] – blazed a trail. Communications experts in the U.S. had alleged that private rights in the use of radio spectrum could not be sufficiently well-defined – "[r]ights to use the spectrum are not susceptible to legal enforcement as are private property rights"[9] – as to support competitive bidding, and political opponents had argued that their use would "emasculate 'socially desirable' censorship."[10]

This view was widely held by policy insiders. Responding to Ronald Coase[11] in 1965, a Federal Communications Commission official wrote: "After the initial shock of rationally considering the use of the pricing mechanism in frequency allocations, the virtually unanimous view of communications specialists would be that the multiplicity of users both national and international…, the interference characteristics of radio with signals at relatively low energy levels interfering at diverse points many hundreds of miles away… and the hundreds of

---

[2] Paging services had been profitable, but were about to be displaced by cellular services. James B. Murray, Jr. WIRELESS NATION (2001).

[3] *Statement by FCC Chairman Kevin J. Martin*, News Release, Federal Communications Commission (March 18, 2009) and FCC website. For a summary of FCC reported auction results, see Appendix 1.

[4] Mark Scanlan, *Hiccups in US Spectrum Auctions*, 25 TELECOMMUNICATIONS POLICY 689 (2001), 690.

[5] See, e.g., Paul Milgrom, PUTTING AUCTION THEORY TO WORK (2004).

[6] Thomas W. Hazlett, *Assigning Property Rights to Radio Spectrum Users: Why Did FCC License Auctions Take 67 Years?* 41 J L & ECON 529 (Oct. 1998).

[7] Robert Crandall, *New Zealand Spectrum Policy: A Model for the United States?* 41 JOURNAL OF LAW & ECONOMICS 821 (Oct. 1998).

[8] R. S. Jain, *Spectrum Auctions in India: Lessons From Experience,* 25 TELECOMMUNICATIONS POLICY 671 (2001).

[9] William H. Melody, *Radio Spectrum Allocation: Role of the Market*, 70 AM ECON REV 393 (May 1980), 392.

[10] As economist Jora Minasian stated the argument against auctions. Jora Minasian, *Property Rights in Radiation: An Alternative Approach to Radio Frequency Allocation*, 18 J L & ECON 221 (1975), 268.

[11] Coase had written an important paper that triggered economic analysis of spectrum allocation. R. H. Coase, *The Federal Communications Commission*, 2 J L & ECON 1 (1959).

thousands of licensees involved in addition to the many millions of consumers make the pricing mechanism un- workable for frequency allocation. Certainly that is my view."[12]

Policy makers did fear a loss of control over broadcasting, and were rational to do so. Assigning rights to radio and television stations by competitive bidding rather than administrative fiat reduced the scope for "regulation by raised eyebrow," as a former FCC Chair characterized the system. The license was commonly referenced as a quid pro quo, with rents awarded to licensees in exchange for "public interest" outputs. In reality, the enumerated social benefits rarely materialized. By the FCC's own admission, the "public interest" programming gambit was a failure, producing a "vast wasteland," as FCC Chairman Newton Minow famously described TV fare in 1961.[13] In 1976, Commissioner Glen O. Robinson likened broadcast regulation to "a charade—a wrestling match full of fake grunts and groans but signifying nothing.''[14] As economist Bruce Owen deduced from the empirical evidence, the FCC "does not live up to its own theory of regulation."[15]

Yet the lack of productive outputs did not mean that the regime was unable to attract powerful adherents. Ronald Coase, arguing for a switch to private property rights in spectrum,[16] found this out. His 1959 FCC testimony was greeted by open contempt; the first question posed was Commissioner Philip Cross' query: "Tell us, Professor, is this all a big joke?"[17] Soon thereafter Coase's detailed proposal commissioned by the Rand Corporation was suppressed when the think tank was warned of explosive political implications.[18] A call for auctions by an FCC member in the 1970s was ridiculed by fellow Commissioners, who gave it the same odds "as those on the Easter Bunny in the Preakness."[19]

Hostility to auctions was particularly prevalent among the oversight committees in Congress where a handful of senators and congressmen held great discretionary power over license assignments. While budget and appropriations committees had long sought to obtain revenues from licenses, the respective commerce committees (overseeing telecommunications regulation) blocked reform. In Feb. 1987, Sen. Warren Rudman (R-NH), a member of the Senate Commerce Committee, sprayed cold water on the Federal Communications Commission proposal to authorize license sales because it ``will aid monopolies…. You won't get anywhere with this, so why don't your go back to the drawing board?"[20] In May 1987, Sen. Daniel Inouye (D-HI), Chair of the Senate Subcommittee on Communications, rebuffed a colleague, Sen.

---

[12] H. H. Goldin, *Discussion of "Evaluation of Public Policy Relating to Television and Radio Broadcasting: Social and Economic Issues" (Coase),* 41 LAND ECONOMICS 167 (May 1965), 168.

[13] Newton R. Minow, EQUAL TIME: THE PRIVATE BROADCASTER AND THE PUBLIC INTEREST (1964), 45-69.

[14] As quoted in Henry Geller, 1995-2005: REGULATORY REFORM FOR PRINCIPAL ELECTRONIC MEDIA (1994), 15.

[15] Bruce M. Owen, *Differing Media, Differing Treatment?* in D. Brenner & W. Rivers, eds., FREE BUT REGULATED: CONFLICTING TRADITIONS IN MEDIA LAW 35 (1982), 36.

[16] R. H. Coase, *The Federal Communications Commission,* 2 J L & ECON 1 (1959).

[17] R. H. Coase, *Law and Economics at Chicago*, 36 J LAW & ECON 239 (1993).

[18] The episode is explained in R. H. Coase, *Assigning Property Rights to Radio Spectrum Users: Why Did FCC License Auctions Take 67 Years?: Comment on Hazlett,* 41 J L & ECON 576 (Oct. 1998).

[19] *Broadcast Renewal Applicant*, 66 F.C.C.2d 419, 434 n.2 (1977) (Commissioners Hooks & Fogarty, separate statement). See Glen O. Robinson, *The Federal Communications Commission: An Essay on Regulatory Watchdogs*, 64 VIRGINIA LAW REVIEW 169 (Mar., 1978), 243.

[20] Evan R. Kwerel & Gregory L. Rosston, *An Insiders' View of FCC Spectrum Auctions*, 17 JOURNAL OF REGULATORY ECONOMICS 253 (2000), 258.

Lawton Chiles (D-FL), Chair of the Senate Budget Committee, telling him that an auction "undercuts the fundamental tenet in communications policy that the airwaves are a limited public resource [and it] is inappropriate to sell such a resource to the highest bidder."[21] The Chair of the House Commerce Committee, John Dingell (D-MI), then introduced 1989 legislation with a section: "PROHIBITION OF SPECTRUM AUCTION."[22] This was a pointed gesture; the FCC had no statutory authority to conduct auctions.

Yet this political animosity was dissipating over time. Broadcasting – the object of the "fundamental tenet in communications policy" – was being eclipsed in economic importance by emerging wireless telephone services. In 1993, with U.S. policy for second generation (2G) services lagging, with a newly unified national government (the Democratic Party controlled both the Presidency and the Congress for the first time in 12 years), with other countries then using auctions, and with the transparent squandering of billions of dollars in rents in the 1984-89 cellular license lotteries as predicate, the system was primed for reform. Congress authorized auctions in the 1993 budget, mandating that they be used to distribute PCS, but not broadcasting, licenses and gave the Federal Communications Commission a one-year deadline to initiate competitive bidding.[23]

The demonstration effect was powerful. Once sales commenced, distributing licenses economically, the consensus of the communications experts was exposed and broken.[24] The burden shifted: *what was to justify a system in which licenses were not assigned to high bidders?* Moreover, the new flow of federal receipts shifted the political equilibrium. Stalwart opponents of auctions now sought to take credit. Pedestrians in Washington D.C. found it hazardous to inadvertently stroll between a television news crew and an FCC Chairman brandishing an auction check for the Treasury. The Commission issued notices boasting that it was a government profit center.[25] While tantamount to a real estate agent assuming credit for the market value of the property sold, the claim did possess a germ of historical veracity: prior to 1994, the Government had squandered such rents in favor of "beauty contests" and lotteries.[26]

---

[21] Ibid.

[22] Ibid.

[23] The process by which the FCC acted quickly to create an auction mechanism is described in Evan Kwerel's Preface to Milgrom (2004). Dr. Kwerel, then and now a Senior Economist at the FCC, was the FCC official who led the agency's auction planning.

[24] Auction rules employed by the FCC were crafted on a strict timeline and reflected an understanding that initial auction outcomes were politically important. Were haphazard procedures to produce confusion, legal challenges, or long delays, the backlash might well eliminate the reforms. FCC staff, largely enthusiastic supporters of auctions, were influential in steering the Commission towards fairly simple auction formats, and to testing mechanisms prior to deployments. While we will see that such caution was soon hedged by the bidder subsidies extended in Auction 5 (May 1996), it was crucial that the first four auctions ran smoothly, resulted in orderly license assignments (and wireless deployments), and collected over $8 billion for the Treasury. See Kwerel & Rosston (2000). See also, Vernon L. Smith & David Porter, *FCC License Auction Design: A 12 Year Experiment*, 3 JOURNAL OF LAW, ECONOMICS & POLICY 63 (2006).

[25] After the March 1995 broadband PCS auction, the FCC "blew up a huge check [of $7.7 billion] to give the President. The picture ran in newspapers across the country. .. I told the press that the FCC had raised more money that its total budget for its 61-year history. We were, I said, the most profitable American business in terms of return on equity." Reed Hundt, YOU SAY YOU WANT A REVOLUTION (1999), 96. (Hundt was Chairman of the Federal Communications Commission, 1993-97.)

[26] Evan Kwerel & Lex Felker, *Using Auctions to Select FCC Licensees*, Federal Communications Commission OPP Working Paper No. 16 (May 1985); http://www.fcc.gov/Bureaus/OPP/working_papers/oppwp16.pdf; Thomas

The policy regime switch exposed a fundamental fact: the use of auctions was not revolutionary. Licenses that had been defined by policymakers before would continue to be defined, if governments so desired, in precisely the same manner. The traditional license, as allocated to television broadcasting, affords a right to operate a wireless business as strictly defined by the license. Transmission technology, business models (ad supported, not subscription), services (broadcast video, not two-way broadband), and even the location of transmitters were specified by regulators. Indeed, for TV and many other services, it still is: "almost all spectrum licenses have restrictions that specify the particular use to which bandwidth must be put."[27] The auction reform formally leaves this regime intact.

Auctions improve initial rights assignments, pre-empting secondary market transactions and allowing efficient license assembly with less cost and greater transparency. When done correctly, with policies that capture these efficiencies without deterring others, the sale of licenses by government is a rent transfer that has no effect on market results. The argument that license sales raise retail prices for wireless applications due to higher costs is rejected by theory.[28] As seen in Figure 1, mobile usage prices do not appear higher in markets where auctions have been used to assign licenses. Cross-country econometric models have, similarly, revealed no statistically significant correlation between auctions and prices.[29] Nonetheless, some business experts and academic economists argue that financial impacts, particularly from auctions reflecting "winner's curse," deter network upgrades.[30]

That debate aside, U.S. auctions have generally produced results in line with what was anticipated by their advocates.[31] Large numbers of licenses have been sold, substantial revenues have been generated for the government, and blocks of spectrum have been more efficiently aggregated, invigorating retail competition. Similar licenses have sold for similar prices, adjusting for timing and other financial differences, and for synergies between licenses.[32]

W. Hazlett & Robert J. Michaels, *The Cost of Rent Seeking: Evidence from FCC Cellular License Lottories,* 53 SO ECON J 435 (Jan. 1993).

[27] Gerald R. Faulhaber, *The Future of Wireless Telecommunications: Spectrum as a Critical Resource*, 18 INFORMATION ECONOMICS & POLICY 256 (2006), 262.

[28] License payments are sunk costs that do not alter retail prices. Evan Kwerel, *Spectrum Auctions Do Not Raise the Price of Wireless Services: Theory and Evidence*, FCC Office of Plans & Policies (Oct. 2000); http://wireless.fcc.gov/auctions/data/papersAndStudies/SpectrumAuctionsDoNotRaisePrices.pdf.

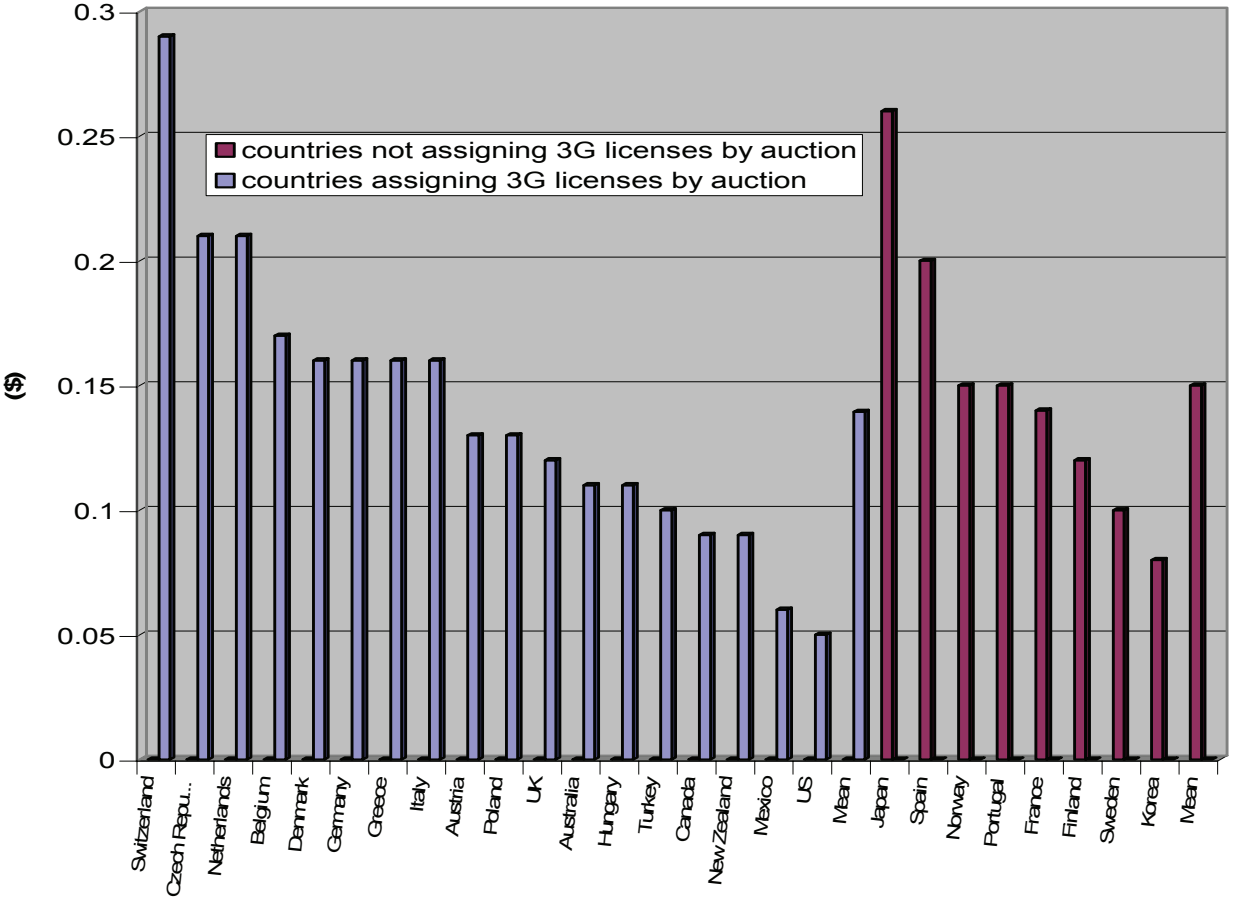
[29] Thomas W. Hazlett & Roberto E. Muñoz, *A Welfare Analysis of Spectrum Allocation Policies*, 40 RAND JOURNAL OF ECONOMICS 224 (Aug. 2009).

[30] Richard D. French, *Governance and Game Theory: When Do Franchise Auctions Induce Firms to Overbid?* 33 TELECOMMUNICATIONS POLICY 164 (2009).

[31] The author was among these advocates. Thomas W. Hazlett, *Making Money Out of the Air,* NY TIMES (Dec. 2, 1987); *Dial 'G' for Giveaway*, BARRON'S (June 4, 1990).

[32] Lawrence Ausubel, Peter Cramton, Preston McAfee and John McMillan, *Synergies in Wireless Telephony: Evidence from the Broadband PCS Auctions*, 6 JOURNAL OF ECONOMICS & MANAGEMENT STRATEGY 497 (1997); Patrick Moreton & Pablo Spiller, *What's In the Air: Interlicense Synergies in the Federal Communications Commission's Broadband Personal Communications Service Spectrum Auctions,* 41 JOURNAL OF LAW & ECONOMICS 677 (Oct. 1998).

FIG. 1. $ REVENUE PER MINUTE IN AUCTION, NON-AUCTION MARKETS (1Q2008)[33]



Yet, problems have emerged with the implementation of U.S. license auctions. One was the ability of bidders to communicate – and collude – by using bids that detailed what markets they were most keenly interested in winning. This was corrected by moving bids into standard unit increments selected by the FCC.[34] Another flaw was the extension of long-term credit to financially weak firms in an attempt to subsidize small businesses and rural telephone carriers. This led to the PCS C block fiasco, resulting in long delays in deploying the underlying spectrum.[35] Because the licenses were in legal limbo for nearly a decade, and because 30 MHz of PCS bandwidth was wasted during this period, consumers paid higher retail prices. The loss in consumer surplus has been estimated to be in excess of $65 billion.[36] This problem was addressed by ending the FCC's role in banking; it no longer extends credit to winning bidders. It continues, however, to favor weak bidders with bidding credits, raising the probability that productive efficiencies will be lost and output markets will exhibit degraded performance.[37]

---

[33] Source: Merrill Lynch Global Matrix (1Q2008).

[34] Peter Cramton & Jesse A. Schwartz, *Collusive Bidding in the FCC Spectrum Auctions*, 1 CONTRIBUTIONS TO ECONOMIC ANALYSIS & POLICY (2002); Patrick Bajari & Jungwon Yeo, *Auction Design and Tacit Collusion in FCC Spectrum Auctions*, NBER Working Paper 14441 (Oct. 2008); http://www.nber.org/papers/w14441.

[35] Thomas W. Hazlett & Babette E. L. Boliek, *Use of Designated Entity Preferences in Assigning Wireless Licenses*, 51 FEDERAL COMMUNICATIONS LAW JOURNAL *639* (May 1999).

[36] Hazlett & Muñoz (2009).

[37] Ibid.

Such procedural flaws appear to most analysts as fixable and, indeed, fixed. "A close examination of the problems experienced in the US in the middle of the 1990s, however, shows that they were relatively minor glitches to a very successful program of spectrum assignment."[38] Yet, deeper challenges continue to confront U.S. spectrum policymakers. These include the following:

- Under-allocation of liberal licenses. Bandwidth rights comparable to 3G licenses were allocated via auctions that were delayed from 2000 until 2008. The argument that delays would increase auction receipts – the "starving man theory of revenue maximization" -- played an important role. Dynamic effects of auctions likely contributed, as well. With rents for entrants eliminated via competitive bidding for licenses, the incentive to invest in regulatory lobbying to obtain competitive access to bandwidth is diminished.

- De-liberalization via restrictions increasingly placed on licenses. This recreates the traditional approach, planning market outcomes by regulatory manipulation of spectrum inputs. The PCS C block debacle was a trial run, 1995-2005. In 2007-08 the FCC reprised the approach with 700 MHz blocks C and D. Out of the 108 MHz of spectrum available from the "digital TV dividend," restrictions on usage (including build-out requirements) have allowed only 48 MHz to be deployed by the market. Another 22 MHz, allocated to C licenses constrained to "open access" business models mandated by the FCC, decreased winning bids between $5 billion and $12 billion – i.e., more than the $4.7 billion sales price.

- License fragmentation continues to complicate license bidding strategies, exposing bidders attempt to create national coverage areas out of hundreds of local licenses to high levels of risk. Lacking combinatorial bidding, long planned but yet to be effectively instituted by the FCC, this complexity reduces auction efficiency. It also requires relatively lengthy auction formats that have resulted in costly non-disclosure restrictions. These rules *reduce* entry, decreasing competition.

In short, auctions have proven a successful innovation, replacing highly inefficient license assignment methods. But they have yet to solve the most pressing spectrum allocation problems. In some cases, they may have exacerbated them.

[38] Mark Scanlan, *Hiccups in US Spectrum Auctions*, 25 TELECOMMUNICATIONS POLICY 689 (2001), 690.

II. Efficiencies of License Auctions

Assigning wireless licenses by competitive bidding has markedly improved the administrative process wherein spectrum rights are awarded to licensees.[39] Efficiencies include private sector savings on lobbying activity associated with "comparative hearings," contests to establish the "public interest" bona fides of rival bidders for licenses. They are also an improvement over lotteries, authorized for use by the U.S. Congress in 1981 as a compromise (Congress not wanting to grant the Reagan Administration auction authority), which were curiously conducted under the fiction that those applying for random selection were actual phone companies. Thousands of new "phone companies" materialized, at least on paper, submitting detailed engineering drawings and proof of operating experience, purchased from consulting firms at considerable cost.[40] This charade created such massive paperwork, with hundreds of thousands of applications submitted for 1,468 cellular licenses (two issued in each of 734 franchise areas), that an FCC warehouse storing these documents collapsed. Between $500 million and $1 billion was squandered in entirely wasteful application processing costs.[41]

But the largest costs were borne by consumers, technology suppliers, and investors after the non-auctioned licenses were assigned. Given U.S. regulators' penchant for issuing large numbers of geographically (and, often, spectrally) small licenses, extensive secondary market transactions were needed to assembly efficient spectrum blocks. To serve a national marketplace with mobile wireless, e.g., operators have acquired literally thousands of licenses. Such aggregations have been expensive; an estimated $190 million on brokers' fees alone was spent in 1991 in cellular license deals.[42]

More deleteriously, it took years to collect assets, delaying and degrading services. The use of auctions in the primary market has speeded this process, reducing social expense. Paul Milgrom references the general set of transaction costs involved in reconfiguring license rights in secondary markets in writing:

> The history of the US wireless telephone service offers direct evidence that the fragmented and inefficient initial distribution of rights was not quickly correctable by market transactions. Despite demands from consumers for nationwide networks and the demonstrated successes of similarly wide networks in Europe, such networks were slow to develop in the United States.[43]

Such post-assignment delays were mitigated with the use of auctions. In the important PCS A, B auction, held from Dec. 1994 to March 1995, one firm – Sprint – emerged with 29 of

---

[39] Peter Cramton, *Spectrum Auctions*, M. Cave, et al., eds., HANDBOOK OF TELECOMMUNICATIONS ECONOMICS VOL. I 605 (2002).

[40] The forms verified that a group of investors could build and operate a cellular phone company, proof of which was purchased from actual telecommunications suppliers in exchange for contracts to provide such services (contingent on the lottery applicants being selected).

[41] Thomas W. Hazlett & Robert J. Michaels, *The Cost of Rent Seeking: Evidence from Cellular Telephone License Lotteries*, 53 SOUTHERN ECONOMIC JOURNAL 425 (Jan. 1993).

[42] Federal Communications Commission, *FCC Report to Congress on Spectrum Auctions*, WT Docket No. 97-150 (Oct. 9, 1997), 22.

[43] Paul Milgrom, PUTTING AUCTION THEORY TO WORK (2004), 20.

51 licenses needed for complete national coverage using 30 MHz. This yielded Sprint – a new mobile entrant -- direct access to 147 million potential subscribers (more than half U.S. population).[44] With roaming agreements, themselves easier to execute given the defragmentation of licenses elsewhere, Sprint began providing services by late 1995. This foray, along with additional regional network consolidations enabled in the PCS A/B auction and the formation of Nextel,[45] disrupted the existing cellular duopoly.

The auction exposed the fact that mobile licenses were complements; significant value was created when adjacent licenses were purchased by bidders.[46] Productive gains were possible via the assembly of efficient packages, eliminating uneconomic rights distributions. The results intensified competitive rivalry, with large gains to consumers. As seen in Figure 2, revenue per minute fell from an average of 51 cents in 1991 (and higher immediately prior to the PCS auction), to just above 10 cents in 2003, a nominal reduction of 79%. Most of this was achieved via a huge increase in minutes of use, encouraged by flat rate (fixed subscription charges) pricing.

Recognizing lags for license assignments (still taking as long as one year post-auction) and network build-outs, retail prices fell precipitously with PCS entry. The form of the competitive battle was not in a simple reduction in customer charges over a fixed menu of services, but rivalry over alternative business models. Operators found that they could profit by offering multipart pricing plans, offering low-cost minutes (off-peak, on-net) at lower (or zero) prices, while extracting revenues via monthly subscription charges. Importantly, firms discovered that they could undercut high long-distance charges, encouraging substitution not only from mobile rivals but from wireline long-distance calling. The key marketing innovation in this battle was, by all accounts, the introduction of popular digital "one rate plans" which put large buckets of "nationwide minutes" into the competitive mix.[47]

---

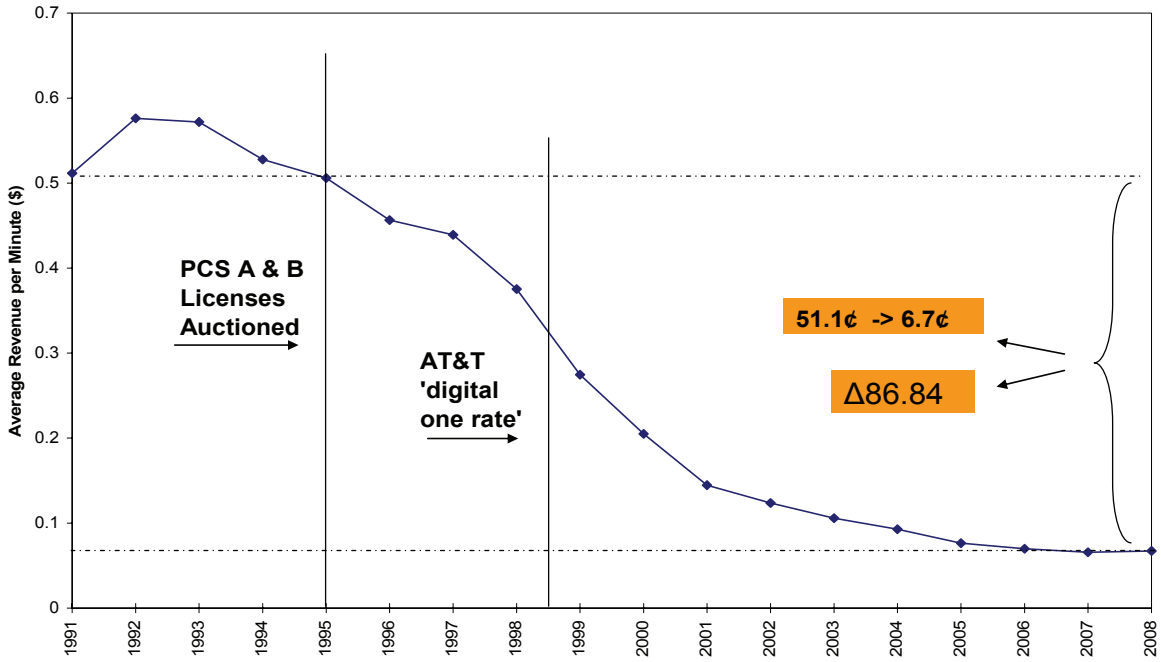
[44] Harold Gruber, THE ECONOMICS OF MOBILE TELECOMMUNICATIONS (2005), 238.

[45] Fleet Call was a wireless operator built on so-called taxi dispatch licenses, officially known as Specialized Mobile Radio (SMR) services. An entrepreneurial former FCC lawyer, Morgan O'Brien, purchased rights to many of these licenses, allocated 800 MHz and 900 MHz spectrum (very near cellular frequencies) and obtained permission from the regulator in 1990 to replace analog systems with digital technologies. In a lobbying coup for the upstart, the request (heavily opposed by incumbent cellular operators) was granted. This enabled the firm, renamed Nextel, to operate on up to 15 MHz. See Thomas W. Hazlett, *The Wireless Craze, the Unlimited Bandwidth Myth, the Spectrum Auctions Faux Pas, and the Punchline to Ronald Coase's 'Big Joke': An Essay on Airwave Allocation Policy,* 14 HARVARD JOURNAL OF LAW & TECHNOLOGY 335 (Spring 2001), 387-88. Nextel served 12 million subscribers before being sold to Sprint for $35 billion in 2005.

[46] See Lawrence Ausubel, Peter Cramton, Preston McAfee and John McMillan, *Synergies in Wireless Telephony: Evidence from the Broadband PCS Auctions*, 6 JOURNAL OF ECONOMICS & MANAGEMENT STRATEGY 497 (1997); (1997); Patrick Moreton & Pablo Spiller, *What's In the Air: Interlicense Synergies in the Federal Communications Commission's Broadband Personal Communications Service Spectrum Auctions,* 41 JOURNAL OF LAW & ECONOMICS 677 (Oct. 1998).

[47] "Buckets" of nationwide minutes (eliminating long distance charges) proved extremely popular. After AT&T Wireless introduced its "Digital One Rate" plan in May 1998, all major carriers quickly adopted similar menus. Federal Communications Commission, *CMRS Fifth Annual Report* (2000).

FIGURE 2. U.S. CELLULAR RETAIL PRICES BEFORE AND AFTER PCS AUCTIONS[48]



The observed efficiency of assignments by competitive bidding may have encouraged regulators to continue to divvy up airwave rights in highly fragmented parcels. In 85 auctions conducted by the FCC, July 1994 through November 2008, the Commission sold some 27,484 licenses.[49] In the mobile phone market (dubbed "CMRS" for Commercial Mobile Radio Services, consisting of cellular, personal communications services [PCS], specialized mobile radio [SMR], advanced wireless services [AWS] and 700 MHz licensees), there are at least 53,774 licenses used by U.S. mobile carriers. The equilibrium number of licenses actually appears to be somewhere about four, given the fact that 90% percent of U.S. mobile service revenues are accounted for by four carriers (Verizon, AT&T, Sprint and T-Mobile).[50] This radical fragmentation of licenses has, to a considerable degree, been mitigated by the implementation of auctions.

Revenues generated by license auctions have assumed both economic and political importance. To economists, the rents transferred to governments create public financing efficiencies. Each dollar raised theoretically offsets another dollar which would have – but for the auction receipts – been raised via taxes. Because taxes generally distort economic activity, funds raised cost society more than they buy for the government. While taxation costs vary widely depending on circumstances, a rule of thumb is that it costs about $0.33 to raise $1.00 for

---

[48] CTIA data.

[49] FCC website. The number is slightly inflated by the re-auction of some licenses.

[50] Approximately 51,597 licenses were held by U.S. carriers in 2003, prior to the auction of 1,087 AWS licenses in Sept. 2006 and 1,090 700 MHz licenses in March 2008. See Appendix 1 for a summary of U.S. license auctions. For the 2003 license distribution across regulatory categories, see Thomas W. Hazlett, *Is Federal Preemption Efficient in Cellular Phone Regulation?* 56 FEDERAL COMMUNICATIONS LAW JOURNAL 155 (Dec. 2003), 193

the government. The corollary, then, is that each dollar raised at auction reduces social costs by about $0.33 – a public financing bonus.[51]

It is politically popular for governments to spend money on projects, and doubly so when such expenditures do not come from taxes. Moreover, the extraction of funds in a transaction with the private sector testifies both to the competence of the government and to the stewardship shown towards public resources. As noted, even those political actors who had long opposed competitive bidding were quick to the podium to announce auction results when billions of dollars were raised for the Treasury.

III. Potential Inefficiencies in the License Auction Regime

1. Continued Use of the State Property Regime to Allocate Spectrum

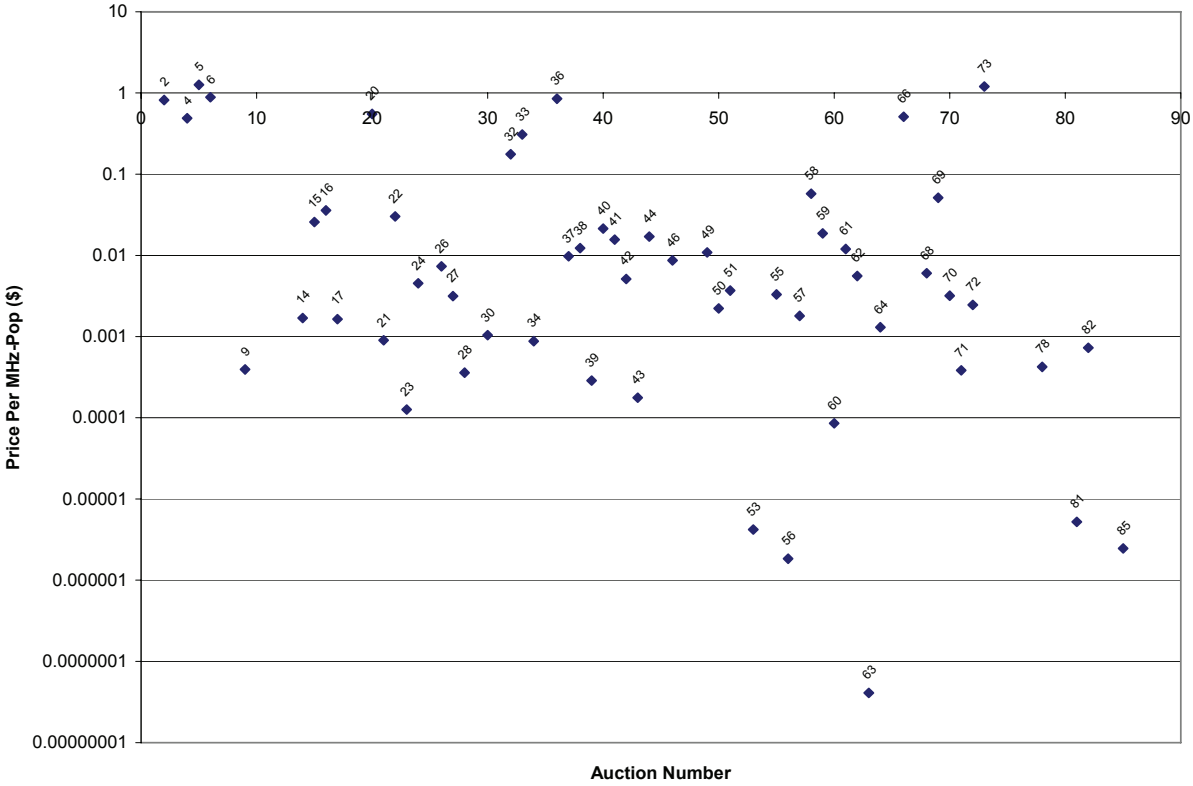
Spectrum policy challenges continue during the era of wireless license auctions. Foremost among these is the fact that the underlying spectrum allocation regime continues to award valuable frequency rights only after expensive, drawn-out, case-by-case proceedings. Often allocations are then made not via liberal licenses, but with regulators' imposing licensing rigidities on wireless operators. The outcome can be observed in widely differing prices paid for licenses allocated very similar spectrum. The differentials reflect not locational factors but regulatory constraints. These constraints can increase the value of a license by limiting competitive entry to a highly profitable wireless market, or decrease value by reducing productive use of airwaves by such a degree that the gains from competitive limits are outweighed. In a study of 24 countries conducting 38 auctions for spectrum used for mobile services, I found that prices paid in countries extending very liberal usage rights to licensees (Australia, New Zealand, Guatemala, and El Salvador) were 61% below the prices paid in other countries, ceteris paribus.[52]

---

[51] Peter Cramton, *Spectrum Auctions*, in M. Cave, et al., eds. HANDBOOK OF TELECOMMUNICATIONS ECONOMICS, VOL. 1 605 (2002).

[52] Thomas W. Hazlett, *Property Rights and Wireless License Values*, 51 JOURNAL OF LAW & ECONOMICS 563 (Aug. 2008).

FIG. 3. PRICE/MHZ/POP ACROSS U.S. LICENSE AUCTIONS, 1994-2008



The degree to which the regulatory system distorts spectrum values is suggested in Figure 3, showing the price (adjusted for MHz and population in the licensed areas) paid across U.S. auctions divided by the mean price paid across all auctions.[53] Although economic factors, including overall market conditions and frequency location, alter bids over time, the extreme variance in FCC license prices is difficult to explain by changing economic circumstances alone. The distinct nature of the rights granted in different licenses, the manner in which spectrum is divvied up (or channelized), and the credits extended to certain auction participants have served to create large price variance. Indeed, three of the ten major auctions (5, 10, 11) experienced severe payment collection problems, and another auction – generating the highest adjusted mean price (35) – resulted in no revenue collection whatever.[54] See Table 2.

This implies that the move to a market in radio spectrum has stalled. Rather than allow competitive forces to distribute frequencies to their highest valued uses, the objective of Ronald Coase's policy recommendation to use the "price system" in lieu of administrative allocation, the traditional regime lives on. Certain licenses have been embedded with broad, flexible spectrum

[53] There have been 72 FCC auctions; the mean price per MHz-pop (equally weighted across auctions) is 23.17¢.

[54] The FCC was selling licenses that the Supreme Court later ruled it did not own. (Bankrupt C and F license winning bidders were determined to own the licenses.)

use rights that permit licensees to determine services, business models, and technologies. In general, licenses used for mobile voice and data services have been liberally endowed.[55]

TABLE 2. PRICE PER MHZ/POP IN MAJOR FCC AUCTIONS[56]

Auction	Description	Date	Revenue (US $mil)	$Price Per MHz/Pop
4	PCS A, B	Mar. 1995	7,019	0.52
5	PCS C	May 1996	13,429	1.77
10	PCS C Re-auction	July 1996	697	1.50
11	PCS D, E, F	Jan. 1997	2,715	0.36
22	PCS	Mar. 1999	533	0.20
34	800 MHz	Sept. 2000	337	0.16
35	PCS C & F	Jan. 2001	17,596	4.37
58	Broadband PCS Re-auction	Jan. 2005	2,250	1.05
66	AWS	Sept. 2006	13,879	0.54
73	700 MHz	Mar. 2008	19,592	1.11

Other licenses, however, remain highly restrictive. This constitutes an admission that regulators seek to promote different services with different licenses, an industrial policy Gerald Faulhaber dubs "GOSPLAN."[57] Satellite radio licenses, for example, permit only national broadcasts; targeted, localized content is prohibited (to protect terrestrial radio stations). Satellite telephone operators are permitted to provide "ancillary terrestrial" mobile services only to augment satellite phone service, despite the fact that "land mobile" might be (likely is) the most efficient use of the band. Guard bands in 700 MHz frequencies have been heavily regulated, with licensees permitted only to operate on a common carriage model imposed by the Commission. The rules have proven unworkable, destroying the value of otherwise productive frequencies.[58]

While Wireless Communications Services (WCS) licenses contained liberal rules as to services, they were highly restrictive as to deployments. To limit interference to adjacent satellite radio operations, rules were imposed that likely pre-empted most valuable applications. Hence, in Auction 14, held in April 1997, a paltry $13.6 million was paid for licenses allocated 25 MHz of nationwide spectrum in the 2.3 GHz band (between PCS and the unlicensed "wi-fi" band). The airwaves went largely unused, but in 2005, a merger with XM Satellite Radio sought to change that. XM proposed to acquire WCS licenses for $197 million, a Coasean solution to

---

[55] Evan Kwerel & John Williams, *A Proposal for A Rapid Transition to Market Allocation of Spectrum*, Federal Communications Commission OPP Working Paper No. 38 (Nov. 15, 2002).

[56] This chart is taken from Table 2 in Jeremy Bulow, Jonathan Levin, and Paul Milgrom, *Winning Play in Spectrum Auctions,* NBER Working Paper 14765 (March 2009). I have added Auction 5 (1995 sale of PCS A and B licenses), which generated over $7 billion, the third largest auction sum collected. Auction 5 data taken from Gruber (2005), p. 237.

[57] Gerald R. Faulhaber, *The Future of Wireless Communications: Spectrum as a Critical Resource*, 18 INFORMATION ECONOMICS & POLICY 256 (2006), 265.

[58] Gregory L. Rosston, *The Long and Winding Road: The FCC Paves the Path With Good Intentions,* 27 TELECOMMUNICATIONS POLICY 501 (Aug. 2003).

the spillover problem.[59] But the FCC, heavily lobbied by terrestrial radio interests, blocked the merger. The spectrum continues to lie fallow.

Whether license auctions have exacerbated the tendency of spectrum misallocation under the regulatory regime is a hypothesis considered below. The conclusion here is that competitive bidding for licenses is easily compatible with a policy regime in which spectrum is allocated as state property.

2. License Fragmentation and the Cost of Auction Complexity

U.S. spectrum policy has been distinctive in its reliance on extreme license fragmentation. Virtually all countries, e.g., issue national licenses for mobile telephone service; a few countries issue large regional licenses. The American policy with respect to cellular was to create 734 local franchise areas, and issue two licenses in each. In PCS, multiple maps were used; A and B blocks consisted of 51 licenses nationwide; C, D, E and F of 493 licenses – 2,074 licenses in all. But SMR licenses (used to supply mobile services in competition with cellular and PCS) are even less concentrated, splitting not only by locality but by channel assignment into more than 47,000 such licenses.

SMR licenses were assigned prior to the advent of FCC auctions; hence, FCC auctions have assigned "only" 27,484 licenses by official count. This splintering of rights is politically driven by Congress' preference for local licenses. The most striking illustration occurred in the TV Allocation Table of 1952. There were already four competing national TV networks – NBC, CBS, ABC, and DuMont – operating via stations broadcasting with temporary authorizations. In finalizing its permanent plan, the FCC considered the proposal of the fledgling network, DuMont, asking for a system of strong regional broadcast stations. This would permit four or more broadcasters to use the powerful VHF band, as interference is mitigated when signals are transmitted from the same location. Were Philadelphia and New York to be served by high-power transmissions blanketing the area, many rivals could co-exist – up to 12, using each of the VHF channels.

The Commission instead selected the CBS plan, which emphasized "localism." This meant that many channel slots would be left blank in New York and Philadelphia so that Allentown or Newark could have stations of their own. This sharply restricted the number of TV stations that the typical household could receive. Unable to reach large audiences to compete with the "big three," the once-popular DuMont exited the market in Sept. 1955. Not for another 31 years, when cable TV systems allowed weak UHF stations to compete with VHF (the signal disparity disappears when broadcast stations are carried by cable), would another national broadcast network emerge.

The formats adopted for license auctions have reflected the "fragmentation preferences" of policy makers. Wireless operators bidding on licenses generally demand regional or nationwide spectrum inputs. This makes licenses complements. On the other hand, the existence of alternative license types within the same auction presents chances for substitution.

---

[59] See Harold Demsetz, *Ownership and the Externality Problem*, T. Anderson & F. McChesney, eds., PROPERTY RIGHTS: COORDINATION, CONFLICT, AND LAW 282 (2008).

At a small cost penalty (in the added complexity in base station and handset radios), bidders can aggregate licenses across bands to achieve their geographic coverage goals.

Taking this general spectrum allocation approach as a given, the economists who helped craft FCC auction rules saw quickly that simple bidding formats – such as sealed bids – would not produce optimal results. Auctions would produce both greater revenue and more efficient results (resources going to the most productive firms) were values of complements and substitutes revealed as bids were being formulated. This led to the now familiar sequential ascending auction (SAA) format, also known as a sequential, multi-round auction (SMR).[60] Inefficiencies yet arise, however, due to risks bidders face in assembling complementary sets of licenses. The solution to this problem is to include package (combinatorial) bids. The FCC rejected this path in 1994, however, given its computational complexity.[61] Despite substantial improvements in auction software and numerous FCC announcements (dating to 2000) that it would adopt such methods,[62] the Commission has yet to effectively deploy package bidding.[63]

In the absence of such aggregate bids, auction participants face exposure, or aggregation, risk. To achieve national coverage, a new entrant must bid on scores of properties without knowing how high prices will go. Should the firm emerge as the high bidder on a number of licenses, but then face a budget constraint as prices climb, it will attempt to exit the auction. But there is no guarantee that it will be outbid on all licenses; the auction may well end with it having the high bid on some fraction of its intended coverage map. It then faces the prospect of unloading its holdings at fire sale prices, or upping its budget to buy 'fill-in' licenses at higher prices than it believed were profitable. Firms can avoid either position by simply choosing not to enter the auction in the first place.[64]

Hence, aggregation risk diminishes competitive bidding processes, lowering revenues and potentially decreasing efficiency in the output market. One indication that this risk is substantial is seen in the premium generally paid for larger licenses where size is measured in geographic space (population, as in "pops") or in frequency space (MHz). The prices paid in the 2006 AWS auction are instructive. See Figure 4. Large regional licenses – D, E, F (12 licenses covering the U.S.) – generally sold for substantially more than did smaller licenses – A (734 licenses), B (176), C (176). The F block, with 20 MHz, sold for more than D and E blocks, allocated 10 MHz each. The larger B and C licenses sold for more than did the smallest licenses, in A.

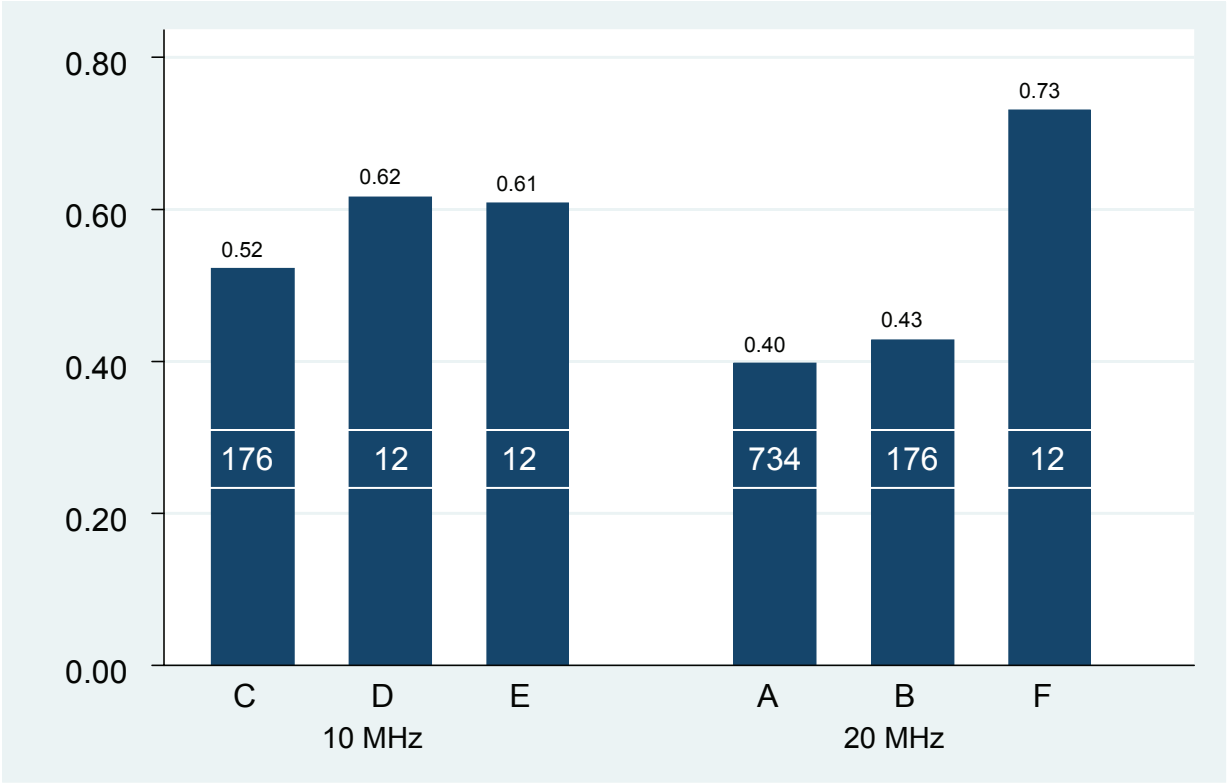
There were anomalies, however. The B band – 20 MHz allocated to 176 licenses – was less expensive than the C band – with 10 MHz distributed across 176 licenses. The (176) B licenses were also cheaper than the (734) A licenses Almost all B licenses were won by SpectrumCo, a consortium of cable companies that held no existing wireless assets. Coleman Bazelon argues that the AWS auction, including the small slicing of licenses and the lack of

---

[60] Smith & Porter, 65-66. See also, Milgrom (2004).
[61] Smith & Porter (2006).
[62] Ibid.
[63] The 700 MHz auction (No. 73) in March 2008 allowed package bids for the 12 large regional licenses, but not for the 1,100 other licenses. Obviously, package bidding is most useful in rationalizing the smaller licenses.
[64] Bulow, Levin & Milgrom (2009).

package bidding, was efficient given that an entrant successfully acquired 20 MHz of national coverage at a price of $2.4 billion – saving $1 billion to $1.5 billion versus what the other two largest auction winners (T-Mobile and Verizon) paid. That was a remarkable outcome.[65] From a social standpoint, such price differentials reveal that the input market has yet to reflect competitive equilibrium. The fact that the event was surprising to many suggests that aggregation risk is a significant issue -- an 'exception that proves the rule.'

Fig. 4. Mean Prices for Different-Sized Licenses in the AWS Auction (Sept. 2006)



At least three policy reforms would promote further progress. The first calls for further liberalization of spectrum use, allowing market access – via liberal licenses -- to more bandwidth. This would add market liquidity, eliminating price differentials. Engorging the supply side would, of course, extend productive opportunities and liquefy capital markets where wireless service providers shop for spectrum inputs.[66]

The second is to deploy combinatorial auctions. This would allow bidders, and particularly entrants into wireless markets, to reduce aggregation risk. This invites wider participation in auctions, increasing revenues, and will tend to direct spectrum inputs to the most productive service providers.

---

[65] Coleman Bazelon, *Too Many Goals: Problems with the 700 MHz Auction*, 21 INFORMATION ECONOMICS & POLICY 115 (2009). Jeremy Bulow, Jonathan Levin and Paul Milgrom are eager to explain the fortuitous SpectrumCo outcome in the AWS auction as the result of superior strategy; they served as bid consultants for SpectrumCo (via Comcast). I share their enthusiasm, as I was likewise a SpectrumCo consultant (via Cox Cable).

[66] Kwerel & Williams (2002).

Third, auctions should be simplified. Combination bids reduce the importance of bidding strategies. Under the current rules and procedures, regulatory processes are very involved, and bidder preparation lengthy. Not only does this directly add expense to both the public and private sector actors, it produces unintended consequences. For instance, in the 700 MHz auction in 2008, "blind bidding" (not disclosing the identity of bidders) was instituted to reduce the prospect of signaling and, perchance, collusion. While potential bidders were required to (confidentially) declare their intention to bid two months before the auction, they were then subject to strict non-disclosure rules. Firm executives involved with bidding were barred from communicating with potential rivals or even third parties, including suppliers and customers, in any manner that could potentially release information relevant to the auction.

Although it is impossible to ascertain how much entry this deterred, the author knows of at least one major U.S. firm that chose not to bid based (as per the company's internal statements) on the expected cost of compliance. Dozens of company managers were considered material to the bid formulation process, and would be constrained to limit even casual communications with a wide range of business contacts, including those presumed uninvolved in the auction.

Hence, as auction complexity grows and rules expand, an attempt to prevent collusive behavior reduces competitive entry into the auction. Recall that U.S. auction design began by taking the political preference for highly fragmented licenses as given. That dictated a format capable of aggregation, and introducing aggregation risk. Combinatorial bids, which could mitigate this risk, have not been implemented due, apparently, to administrative stasis.[67] To protect this unnecessarily complicated system against anti-competitive collaboration, costly rules are imposed – that reduce competitiveness. It is appropriate to consider whether a switch to national licenses, in lieu of package bidding, would allow simpler procedures (say, sealed bids) that reduced time inputs and the cost quarantining valuable executives.

3. Bidding Credits

In the 1993 legislation authorizing auctions, Congress mandated that the FCC conduct its competitive bidding procedures so as to fully include "designated entities." These were defined to include four groups of firms, including "small businesses" and firms owned by minorities and/or women.

There is a tension between auctions and preferences. When a group such as "small business" is afforded a bidding credit, it tends to attract more intense bidding such that the advantage afforded by the credit disappears. This outcome was virtually assured by the designation "small business," and the rules that the FCC used to define such entities: firms with limited financial resources and no collateral. This was done on the premise that the government sought to help firms that would otherwise have difficulty obtaining credit in order to bid for licenses. Of course, the reason that firms without financial standing have limited access to capital markets is that such firms are generally bad bets.

---

[67] It is possible that economic consultants have become lobbyists for auction complexity. To the extent that package bidding reduces the role of bid strategy, consultants would suffer a wealth loss with efficient reform.

In the 1996 PCS C block auction (No. 5), the FCC saw winning bids more than twice as high, net of bidding credits, as had been paid in the (unsubsidized PCS A and B) auction the year before. Importantly, not only were DE bidders extended 40% bidding credits (bid $100, get credit for a bid of $140), but they were allowed to pay winning bids over ten years, interest-only for the first four, at an interest rate equal to that paid on long-term debt by the U.S. Government. This constituted a very considerable financing subsidy. Moreover, it created a lucrative option. Bidders could bid high to win; make their first payment; then see if the value of licenses exceeded what they had bid. If so, they would finance their network build-out and pay the government. If not, they could declare bankruptcy and seek protection from their creditor – the federal government. Indeed, they could ask a bankruptcy court to reduce their obligation. That is what the largest C block winners did.[68]

The process destroyed huge increments of consumer welfare. The FCC ended up running an auction in 1996 (5) that generated bids largely uncollected; it then ran a re-auction in 2001 (35) that attracted nearly $17 billion in winning bids that went entirely uncollected. This is because the courts ruled that the FCC did not own the re-auctioned licenses, the bankrupt parties (previous auction winners) did. The social cost of the chaotic legal process was found in the wasted spectrum. While the PCS spectrum had been allocated in the 1989-94 period, it took until 1996 to auction C licenses with special DE credits, and then another nine years – until Auction 58 in 2005 – to effectively assign C block licenses to operators. This deprived the mobile market of nearly 30 MHz of nationwide bandwidth, raising prices to retail customers. The loss in efficiency of this input truncation amounted to at least $65 billion.[69]

The interesting aspect of this for economists is that the use of DE bidding credits had been suggested as a good strategy for policy makers. The argument was that strengthening weak bidders would force the hand of strong bidders; higher prices would be generated and, thereby, larger public financing dividends. Evidence from earlier FCC auctions that used bidding credits suggested that this could indeed be the result.

But the excluded consideration was the expected cost of such auction rules. Weak bidders will predictably perform less productively than strong bidders in supplying services. Indeed, a major argument for the efficiency of auctions is that the stronger bidders will win resources and out-produce weaker producers which would otherwise – under comparative hearings or lotteries -- be granted licenses. Given the actual performance of bidding credits, costs have clearly outweighed benefits.

4. Under-allocation of Radio Spectrum

The central problem in spectrum policy is the endemic under-allocation of bandwidth. Owing to the dynamics of "public interest" determinations, which invite rent seeking by

[68] Hazlett & Boliek (1999).
[69] Hazlett & Muñoz (2009).

incumbents, legislators, regulators, and others, U.S. policymakers persistently "warehouse" valuable airwaves, dissipating social value.[70]

License auctions impact this inefficient equilibrium in perhaps a surprising way. Potential entrants – innovators seeking bandwidth to deploy with new wireless devices, for instance – are taxed via competitive bidding mechanisms. This flows from the bi-level nature of the regulatory process. First, an entrant must obtain an FCC spectrum allocation via a decision by the agency to create new licenses[71] that are capable of accommodating the new service. Second, the entrant must obtain one or more of the licenses created in the allocation. There are risks of failure at either level; unless both the allocation and the license are obtained, the entrant wastes any investment in promoting regulatory change.

Under the comparative hearing system, there was an implicit property right awarded to lobbyists for new allocations: if the Commission was persuaded to allocate spectrum for a new service, those who had petitioned the agency to achieve this policy would likely stand first in line, ahead of rival license applicants. With the switch to auctions, the queue is eliminated. The returns to innovation are thereby reduced. That part of the innovation that is specific to developing a new FCC allocation receives no payment. Competitors will free ride on the innovator's efforts, having equal standing in the auction.[72]

The Northpoint Technology example is illustrative. In 1994, a firm with a method for re-using satellite TV spectrum patented their system and approached the FCC, requesting licensed spectrum. The firm received an experimental license, but the Commission was slow to move on the requested allocation. Finally, after a legislative mandate from Congress, the Commission had the technology tested by a third party laboratory. The verdict was that the 500 MHz satellite TV band (12.2 GHz to 12.7 GHz) could accommodate an additional entrant providing video and data service,[73] just as Northpoint had argued. In 2002, after the firm had invested more than $10 million in engineering studies, lawyers' fees, and lobbying costs, the FCC determined that a new spectrum allocation[74] – for Multichannel Video and Data Distribution Services (MVDDS) – would be authorized. Chairman Michael Powell, joined by Commissioner Kathleen Abernathy, were ebullient in their praise for the firm that had made the new service possible. .

> Northpoint arrived at the Commission many years ago with a proposal for a new and innovative way to share the DBS spectrum. Today, thanks in large part to its fine work

---

[70] Coase (1959); Rosston et al. (2001); Thomas W. Hazlett, *Optimal Abolition of FCC Allocation of Radio Spectrum*, 22 JOURNAL OF ECONOMIC PERSPECTIVES 103 (Winter 2008a).

[71] Here I deal with the request for licensed, as opposed to unlicensed, bandwidth.

[72] It is perhaps too little understood that the regulator is essentially passive. As a rule, new ideas are generated by private parties, who then reveal them to the Commission. The Commission, indeed, is structured to respond to petitions or complaints, not to create initiatives on its own. Information is thus revealed to the FCC out of regard for self-interest (by petitioners).

[73] "'This will be the Southwest Airlines of subscription television,' said Sophia Collier, the president of Northpoint Technology, the small company that originally envisioned the technology. Northpoint (not to be confused with NorthPoint Communications, a bankrupt broadband Internet provider) has long said it could offer 96 digital channels and high-speed Internet access for a total of $40 a month -- versus the $80 to $100 that cable companies typically charge now." Jennifer Lee, *Many Bidders May Pursue New Method to Carry TV*, N.Y. TIMES (April 30, 2002).

[74] Stephen Labaton, *An Earthly Idea for Doubling the Airwaves*, N.Y. TIMES (April 3, 2001).

> and diligence, that service will go forward. Many have claimed that Northpoint deserves a nationwide 500 MHz terrestrial license for free based on its regulatory and technical efforts to make this service a reality. We sympathize with the sentiments that underlie these claims. There is little question that had it not been for Northpoint, the MVDDS service would not be ready to move forward today. Northpoint has put significant time and resources into developing its service model as well as its Commission and congressional advocacy over a long period of time. We applaud these efforts. But the statute does not support exempting this spectrum from auction nor does it grant Northpoint the exclusive privilege it seeks... If Northpoint's service model is a winner, the market will reward it just as it has done for other technology companies.[75]

All MVDDS licenses were to auctioned in Jan. 2004 (Auction 53), with the government collecting $118 million. Northpoint did not participate. The rights were bought by incumbent cable and satellite operators, who have yet to develop the service. Northpoint has ceased operations. While the FCC completed Northpoint's requested allocation, the entrepreneurs did not receive any compensation for their investment in the process. Instead, their business model was appropriated and sold to the highest bidder.

The FCC's position was that, were Northpoint the most efficient service provider, they would emerge the high bidder. In fact, it was unlikely that Northpoint was the most efficient *service provider*; as a technology innovator they would logically have searched for a service distributor (Verizon, Radio Shack, Best Buy, e.g.) to partner with, leveraging existing networks. What Northpoint had uniquely achieved was the creation of a *new spectrum allocation*.

License auctions are designed to eliminate wasteful rent seeking, a useful contribution. But they may simultaneously reduce incentives for productive rent seeking.[76] This lessens pressure for spectrum allocations. The strategy of liberalization, of which license auctions are a key component, may include offsets. The demonstration effect of market allocation of licenses may itself propel reforms that generally enable more bandwidth to be used by market participants. This may be observed in countries that have, in instituting auctions, jumped ahead to also reform the underlying allocation regime.[77]

In the U.S., however, weakened pressure for new allocations, combined with political arguments favoring revenue maximization, produced a spectrum drought, 1996-2005. While other countries allocated substantial new bandwidth to mobile operators for 3G services, U.S. carriers spent a decade waiting. The U.S. had been slow to allocate 2G (PCS) licenses, while EU countries substantially completed this task 1989-1992. After the U.S. auction of PCS A and B licenses (allocated 60 MHz of total bandwidth) in 1995, just 20 MHz (PCS D, E) was made available in 1996, followed by a lack of further allocations until the AWS auction in Sept.

---

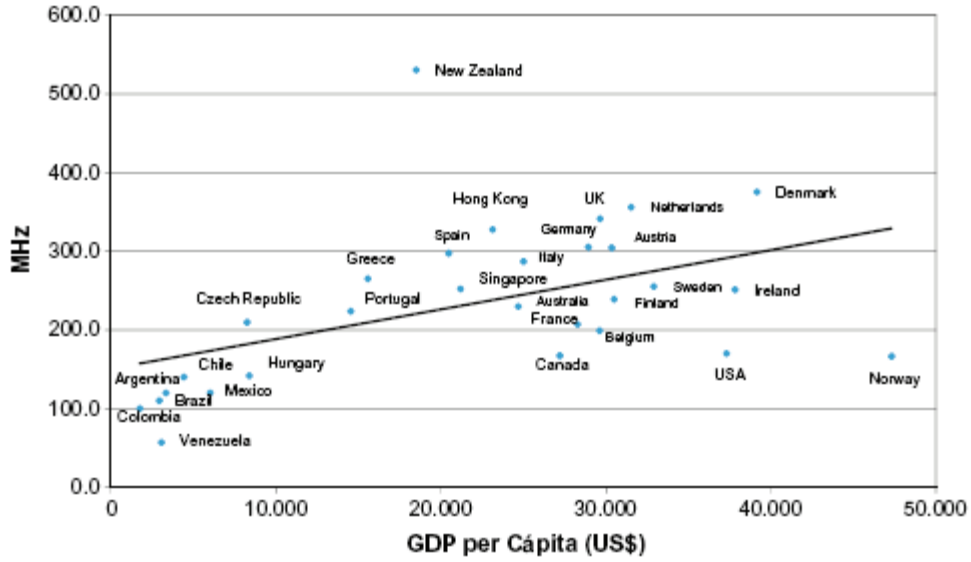
[75] Federal Communications Commission, *In the Matter of Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operation of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-Band Frequency Range: Memorandum Opinion and Order and Second Report and Order*, ET Docket No. 98-206 (rel. May 23, 2002), Joint Statement of Chairman Michael Powell and Commissioner Kathleen Q. Abernathy, 6-7.

[76] The importance of rent seeking for the provision of valuable public goods was articulated in Dwight Lee, *In Defense of Excessive Government*, 65 SOUTHERN ECONOMIC JOURNAL (1999).

[77] In addition to the previously mentioned countries (Australia, New Zealand, Guatemala and El Salvador), the U.K. and Norway have promoted generic liberalization programs.

2006.[78] The U.S. mobile market suffered in comparison with other countries. The 2003 comparison in Figure 5 shows spectrum availability across markets.

FIG. 5. SPECTRUM AVAILABLE TO MOBILE CARRIERS ACROSS COUNTRIES (2003)[79]



The lagging position of the U.S. did not go unnoticed; Congress mandated additional auctions, using TV band spectrum, beginning in 2000. But the FCC, lobbied by incumbent carriers to delay new license sales, postponed these auctions. When taking office, the Bush Administration joined this campaign, pressing regulators to move the auctions back at least 2-4 years.[80] The actual lag was eight years, as the spectrum involved was the 700 MHz frequencies allocated to licenses bid for in March 2008. The argument made was that the delay would be a "win win," meaning that incumbent carriers would be better off *and* the government would end up with higher auction revenues. The consumer welfare lost to a lack of network capacity was excluded from the appraisal.

Part of the rationale hinged on an encumbrance problem: some 700 MHz spectrum was used by analog TV stations that would broadcast until the analog switch-off, which eventually occurred June 12, 2009. The Bush Administration explicitly said that bids would be higher when the switch-off date was closer. Prices would rise over time, as demand for bandwidth intensified – the "starving man theory" of spectrum allocation. As time to switch-over decreased, moreover, the probability that the incumbent stations would vacate would also increase – assuming that the political decision to transition to all-digital transmissions did not become undone. In the interim, few stations were using channels 52-69. By delaying license assignments, the opportunity to use the far more numerous vacant channels, or to allow new licensees to negotiate deals to have the broadcast stations go dark early, was lost.

---

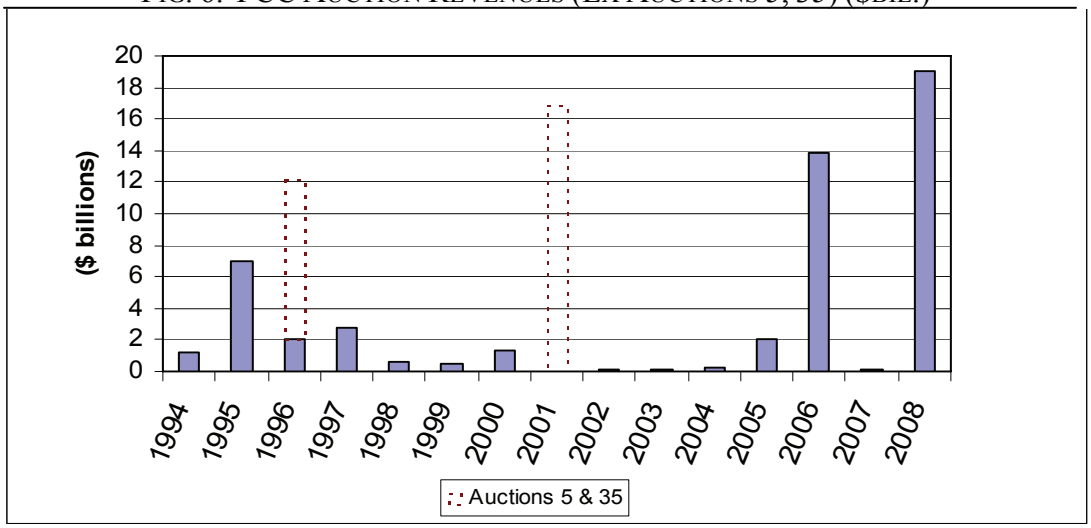
[78] The PCS C block (30 MHz) and F block (10 MHz) were tied up in defaults and bankruptcy disputes, as noted.

[79] Source: Thomas W. Hazlett & Roberto E. Muñoz, *Spectrum Allocation in Latin America: An Economic Analysis*, INFORMATION ECONOMICS & POLICY (In Press, 2009).

[80] Patrick Ross, *Bush Wants to Delay Airwaves Auction*, CNET NEWS.COM (April 9, 2001).

During the drought period, policy makers explicitly sought to delay auctions. The sale of 3G licenses throughout the European Union in 2000-2001 was not met with any response by U.S. regulators until the Sept. 2006 AWS auction. Up until then, the EU average spectrum allocation available to carriers was about 266 MHz, while U.S. networks used just 150 MHz (remembering the 40 MHz tied up in PCS C and F licenses). The flow of revenues collected (which excludes the auctions 5 and 35 due to their payment deficiencies) tells the story. See Figure 6. After assigned PCS A and B licenses, regulators backed off for over a decade. The 90 MHz allocated to AWS licenses sold in Sept. 2006 and the 52 MHz allocated to 700 MHz licenses sold in March 2008 account for $33 billion in receipts – some 62% of total revenues collected, July 1994- July 2009.

FIG. 6. FCC AUCTION REVENUES (EX AUCTIONS 5, 35) ($BIL.)[81]



One consequence of the spectrum drought period was that major U.S. carriers merged. In 2004, there were six major nationwide carriers: Verizon, Cingular, AT&T Wireless, Sprint, T-Mobile, and Nextel. In 2004-05, however, Cingular (a joint venture of SBC and BellSouth) acquired AT&T Wireless for $41 billion, while Sprint bought Nextel for $35 billion. When the dust settled, six national competitors were reduced to four. The two combinations were both driven, in large part, by a demand to access additional bandwidth, and both networks launched 3G upgrades post-merger.[82] T-Mobile, which did not acquire additional significant spectrum during the drought period, had to delay the its 3G products.[83] until 2008, when its newly

[81] Source: FCC (see Appendix 1). Auction 5 (PCS C) produced bids that largely went uncollected. Auction 35 (PCS C re-auction) bids went entirely uncollected.

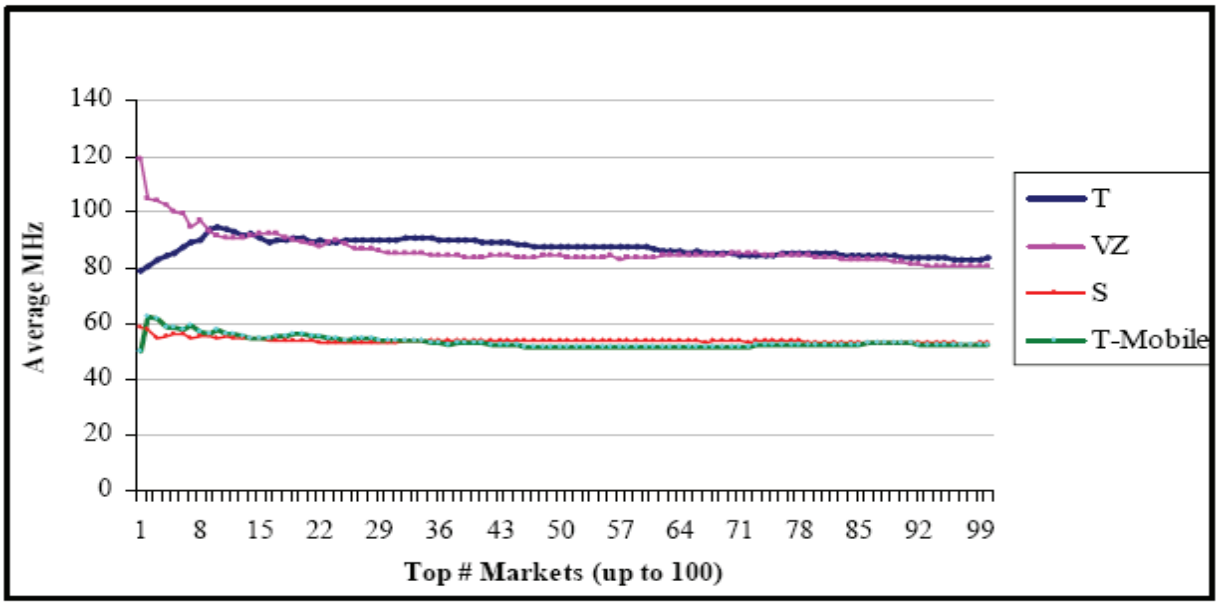
[82] "Cingular Wireless, the nation's largest cellphone service provider, announced plans yesterday to upgrade its high-speed data network, allowing faster downloads than are now available on many home broadband connections. The upgrade will start at the end of 2005, and the network will be in place nationwide by 2006, Cingular said. .. In October, Cingular Wireless closed its acquisition of AT&T Wireless, creating the nation's largest wireless company with 47 million subscribers. Cingular said the acquisition gave it the additional radio spectrum necessary to deploy the high-speed network." **Matt Richtel, Cingular to Upgrade Data Network, N. Y. TIMES (Dec. 1, 2004).**

[83] "T-Mobile USA Inc. continues to lag behind its competitors in offering wide-area next-generation services, as the carrier is still working on deploying EDGE services. The carrier also has stated it will be at least two years

purchased bandwidth – it was the largest winning bidder in the AWS auction, spending $4.2 billion on licenses – enabled the roll-out of new high-speed data services with a network upgrade costing $2.7 billion.[84]

The current spectrum holdings of the four national carriers are seen in Figure 7. By aggregating licenses, network operators have assembled bandwidth blocks of consistent size (and, although not shown, frequencies). The relentlessness of market incentives masks a good deal of inefficiency. Milgrom criticizes the laissez-faire attitude that initial assignments do not matter much, so long as the rights are "in the market."[85] It is important to note the costs of rationalizing scattered assets; institutions should be shaped to reduce such social expense.

FIG. 7. DISTRIBUTION OF MOBILE CARRIER BANDWIDTH[86]



5. De-liberalization of Spectrum Allocation.

---

before it has enough spectrum capacity to launch a UMTS-based network." Dan Meyer, *Verizon expands EV-DO, Cingular says it's under no pressure to match speed,* RCR WIRELESS NEWS (July 4, 2005).

[84] Laurie Sullivan, *T-Mobile Plans Major Cellular Upgrade To 3G*, INFORMATION WEEK (Oct. 16, 2006).

[85] Milgrom (2004), pp. 19-21.

[86] Source: Blair Levin, *What 700 MHz Winners Can Do With Their Spectrum*, Stifel Nicolas (April 15, 2008), p. 4. T=AT&T; VZ=Verizon; S=Sprint.

Driven both by an intellectual consensus among economists[87] and social demands to adopt more efficient license distributions,[88] U.S. spectrum allocation underwent a quiet but striking period of deregulatory reform, 1975-2000. During that time private satellites were authorized, cable TV operators were allowed to compete with broadcasters, content rules were relaxed for radio and TV stations, satellite TV and radio operators were licensed, and cellular and PCS licenses were issued. Spectrum policy was fundamentally altered in the liberalization of mobile licenses; initially, cellular operators were mandated to provide a particular service with a given (analog) technology, and the location of transmission facilities was fixed in the license.

By the time PCS permits were allocated in 1995, operators could select their own (digital) technology, provide voice, data, or video services, and had wide latitude in choice of business models. Disparate licenses – cellular, SMR, PCS – were unified under the CMRS (Commercial Mobile Radio Service) regime, allowing flexibility to licensees and promoting competition across otherwise disparate markets. The policy objective shifted from detailed specification of technology, equipment, network architecture, and service, to an effort to "license spectrum." While subtle in terms of the bureaucratic process – administrative procedures remained in place, the FCC was not materially reformed, and no statute forced this policy migration -- the implications were profound.

In lieu of spectrum being held by regulators and then parceled out for specific uses to specific users, de facto spectrum ownership rights were assigned to private parties. Frequency sharing choices were delegated to licensees. The regulator's primary task was to distribute rights to encourage competition by privatizing resources.

Still, the traditional administrative system for assigning "high level" spectrum rights remained in place. And in recent years the political equilibrium at the FCC has retreated, slowing or reversing the path to liberal licenses. Important policies to result include the allocation of a 50 MHz "WiMax" band (3650-3700 MHz) for unlicensed rather than licensed use in 2005; the 700 MHz C block "open access" rules adopted in 2007; the 700 MHz D block "public safety" license plan adopted in 2007; and the TV band "white spaces" allocation for unlicensed devices (sharing the 294 MHz of "DTV spectrum") in 2008.

- *3650-3700 MHz*. A swath of 50 MHz adjacent to 3.5 GHz, the most popular international band for emerging WiMax services, was set aside for unlicensed devices in a 2005 Order. The FCC rejected a proposal from Intel and Alvarion (ironically, two of the largest manufacturing firms in the unlicensed device space) to allocate the bandwidth to liberal licenses. Instead, it issued non-exclusive use rights while requiring a registration system (to identify the location of transmissions) for users and mandating that operators adopt reasonable "contention-based protocols" to mitigate interference. This approach shifts the task of devising and regulating spectrum sharing etiquettes from profit-maximizing firms to the government.[89]

---

[87] See Gregory L. Rosston et al., *Comments of 37 Concerned Economists*, Comment submitted to the Federal Communications Commission, WT Docket No. 00-230 (Feb. 7, 2001).

[88] For theoretical and empirical discussions of how spectrum policy has been reformed, see Hazlett (2001, 1998).

[89] Jerry Brito, *The Spectrum Commons in Theory and Practice*, STANFORD TECHNOLOGY LAW REVIEW (2007).

- *700 MHz C License "Open Access" Rules*. In crafting rules for the licenses to be auctioned in 2008 the FCC determined that the winner of the 22 MHz C license (the largest in the auction) would be obligated to provide non-discriminatory network access for all devices and applications.[90] This mandate leaves many details unanswered; it is not clear how far *prices* and *technologies* – as distinct from Acceptable Use Policies – may exclude devices or applications. Verizon won the C block, capturing a discount attributed, at least in part, to the regulatory liability assumed.[91] If the discount resulted in superior retail market performance, it could well be justified. Yet, as seen in the current rivalry between RIM Blackberry, Apple iPhone, and Google gPhone, platform competitive business models locate across an "open–closed" continuum.[92] It is not the case that "open" access models invariably outperform. Categorical restrictions by regulators diminish rivalry, tax the innovative process, and foreclose valuable options. This approach re-institutes the license rigidities of traditional spectrum regulation.

- *700 MHz D Block*. The FCC imposed expensive obligations on the 10 MHz D license, requiring the winning bidder to give priority access to public safety agencies (fire, police, emergency 'first responders') in a hybrid (commercial/public safety) wireless network. Extensive build-out obligations were also imposed, requiring network coverage of 75% of U.S. population by 2013, 95% by 2016 and 99.3% by 2019. No bid exceeded the reserve price of $1.3 billion. At the mean price/MHz-pop for A, B, C, and E licenses, D would have generated $3.9 billion. Instead, 10 MHz lies dormant.

One measure of the level of regulatory tinkering is given in the price differentials. See Table 3. In the 700 MHz license auction the underlying spectrum was virtually identical across properties.[93] Yet price variance was large. The C block sold for 29% of the adjusted price of the B block despite the aggregation premium on the larger-bandwidth C licenses. The C

---

[90] The C Licensee is mandated by the FCC not to:

- Block, degrade, or interfere with the ability of end users to download and utilize applications of their choosing on the licensee's Block C network, subject to reasonable network management. Wireless service providers subject to this requirement will not be allowed to disable features or functionality in handsets where such action is not related to reasonable network management and protection, or compliance with applicable regulatory requirements. For example, providers may not "lock" handsets to prevent their transfer from one system to another.
- Block Wi-Fi access, MP3 playback ringtone capability, or other services that compete with wireless service providers' own offerings.
- Exclude applications or devices solely on the basis that such applications or devices would unreasonably increase bandwidth demands.
- Impose any additional discriminatory charges (one-time or recurring) or conditions on customers who seek to use devices or applications outside of those provided by the licensee.
- Deny access to a customer's device solely because that device makes use of other wireless spectrum bands, such as cellular or PCS spectrum.

Bingham Law firm summary (Aug. 15, 2007); http://www.bingham.com/Media.aspx?MediaID=5492.

[91] Other factors in the auction design are likely contributors, as well. See Bazelon (2009).

[92] Thomas W. Hazlett, *Modularity of Mobile Networks: Is the iPhone iPhony*? Paper presented at the Microsoft/GMU Conference on Innovation (May 7, 2009).

[93] Boundary conditions were a bit different. The A licenses were allocated spectrum adjacent to TV Channel 51, e.g., where digital television broadcasts would cause some conflicts in (relatively few) markets where such TV stations broadcast. Another difference was that the E license was offered as a single "block" and not as "paired" spectrum. This, however, reflects administrative discretion.

licenses, at B prices, would have cost Verizon nearly $16.6 billion -- $11.8 billion more. Of course, the D license did not sell, even at a reserve price one-third of the average obtained for the other licenses. This is evidence that regulatory rules and spectrum allocation procedures continue to distort markets. Bandwidth continues to be allocated not to where consumers desire it to be used, but where administrative mechanisms steer it.[94]

Table 3. Average Prices for Different Licenses in 700 MHz Auction (March 2008)

Block	*Net Winning Bids ($)*	*MHz * Pops*	*$/MHz/pop*
A	3,875,663,800	3,419,018,088	1.13
B	9,068,382,850	3,419,018,088	2.65
C	4,746,691,000	6,283,649,790	0.76
E	1,266,844,500	1,713,722,670	0.74
TOTAL	18,957,582,150	14,833,358,892	1.28

Source: Blair Levin, *Special Focus: The Wireless World After 700 MHz*, Stifel Nicolas (March, 2008), p. 4.

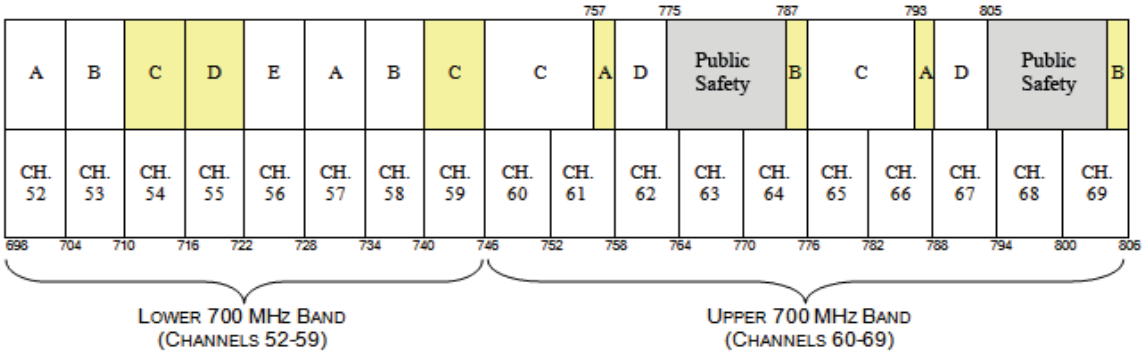
The case-by-case allocation process works slowly and produces modest results. With the (22-year) transition to all-digital broadcasting, the FCC was able to move (analog) stations out of the 52-69 channel range. This yielded some 108 MHz (= 18 * 6 MHz per channel) for new uses. Of that, just 70 MHz was salvaged for competitive bidding -- 18 MHz in Auctions 44 (2002) and 49 (2003), and 52 MHz in Auction 73 (2008). Some 24 MHz was allocated directly to public safety organizations, another 10 MHz lies in the (unsold) D band, and 4 MHz is tied up in guard bands that are virtually worthless under restrictive FCC rules.[95] See Figure 8. Given the extremely inefficient manner in which public safety spectrum is utilized,[96] the marginal gain to society from another 24 MHz allocation is likely to be negative (accounting for the opportunity costs of radio waves).

FIG. 8. FCC BAND PLAN FOR 700 MHZ AUCTION (JANUARY-MARCH, 2008)

[94] In placing "open access" requirements on the C license, FCC policy makers effectively allocated spectrum for the benefit of application providers like Google that lobbied for the rules. By allowing such firms to direct resources without absorbing the costs of the resulting allocation, free rider problems emerge. See Sandro Brusco, Giuseppe Lopomo & Leslie Marx, *The 'Google Effect' in the FCC's 700 MHz Auction*, 21 INFORMATION ECONOMICS & POLICY 101 (2009).

[95] Rosston (2003).

[96] See, e.g., Jon M. Peha, *Fundamental Reform in Public Safety Communications Policy*, 59 FEDERAL COMMUNICATIONS LAW JOURNAL 517 (March 2007).



Block	Frequencies	Bandwidth	Pairing	Area Type	Licenses
A	698-704, 728-734	12 MHz	2 x 6 MHz	EA	176
B	704-710, 734-740	12 MHz	2 x 6 MHz	CMA	734
C	710-716, 740-746	12 MHz	2 x 6 MHz	CMA	734*
D	716-722	6 MHz	unpaired	EAG	6*
E	722-728	6 MHz	unpaired	EA	176
C	746-757, 776-787	22 MHz	2 x 11 MHz	REAG	12
D	758-763, 788-793	10 MHz	2 x 5 MHz	Nationwide	1**
A	757-758, 787-788	2 MHz	2 x 1 MHz	MEA	52***
B	775-776, 805-806	2 MHz	2 x 1 MHz	MEA	52***

*Blocks have been auctioned.
**Block is associated with the 700 MHz Public/Private Partnership.
***Guard Bands blocks have been auctioned, but are being relocated.

More ominously, the remaining 294 MHz of prime spectrum in the digital TV band remains allocated for over-the-air broadcasting. Over 90% of U.S. viewing takes place in households subscribing to cable or satellite systems. At a very modest social cost, the remaining ten percent could do so, as well.[97] By adding unlicensed devices into the "white spaces" that populate most of this band, regulators are assuring – via tragedy of the anti-commons – that the negotiated movement of TV stations onto alternative distribution platforms cannot be executed. The "killer app" of 1952 will continue to dominate this band for generations to come.[98] Watching these protean airwaves go to waste frustrates those who understand the opportunities lost. As former FCC Chief Economist Gerald Faulhaber wrote in 2006:

> The sorry result is that cellular companies are straining within their bandwidth restrictions and are unable to obtain new bandwidth to expand their business. Meanwhile, large amounts of bandwidth are currently occupied by VHF and UHF television broadcasters, even as the audience for broadcast-delivered TV shrinks…[99]

There was a thaw in mobile license auctions 2006-08. But valuable applications are yet deterred; the constraints of administrative spectrum allocation still bind. For generations of

---

[97] Thomas W. Hazlett, *A Letter to the New FCC Chair, Julius Genachowski*, FINANCIAL TIMES (June 25, 2009); http://www.ft.com/cms/s/0/2a99223e-62b2-11de-b1c9-00144feabdc0.html?nclick_check=1.

[98] Thomas W. Hazlett, *The Digital TV Transition: Time to Toss the Negroponte Switch*, AEI-Brookings Joint Center for Regulatory Studies Working Paper No. 01-15 (Nov. 2001).

[99] Gerald R. Faulhaber, *The Future of Wireless Communications: Spectrum as a Critical Resource*, 18 INFORMATION ECONOMICS & POLICY 256 (2006), 262.

technology beyond 3G/4G, television band airwaves would supply highly productive inputs. Marshalling those resources will prove difficult under current regulatory approaches.

IV. Conclusion

Auctions are generally an efficient tool for assigning exclusive rights.[100] They eliminate many costs of alternative methods, and bring transparency to government awards. Simultaneously, they create challenges of their own. In eliminating license rents, they reduce the incentive for either entrants or incumbents to pressure for new allocations from regulators. With diminished momentum for spectrum liberalization, the void has been filled with welfare-diminishing regulatory activity.

Over 15 years the FCC has conducted 72 auctions, sold 27,000 licenses, and collected $53 billion. A rule of thumb suggests that the social benefit of raising these funds for the government is on the order of one-third, or about $18 billion. Reductions in wasteful rent-seeking may amount to a few billion more.

Now consider that these licenses enable markets to supply services from satellite television to satellite radio, from PCS to WiMax. In just one of these applications – mobile telephony – *annual* service revenues sum to $147 billion, with *annual* consumer surplus conservatively estimated to exceed an additional $150 billion.[101] Hence, the social gains from competitive rivalry, including those facilitating new network services such as wireless broadband, dominate whatever social gains are squeezed out of license auctions by well over an order of magnitude. This should focus our attention. Rules that impede competitive rivalry or delay the productive use of spectrum are highly likely to flunk the cost-benefit test.[102]

It is often remarked that, with auctions, policy makers single-mindedly focus on revenue generation. So far as it goes, that hypothesis is rejected by the data. Many opportunities for revenue have been squandered by U.S. regulators. Although it is true that a narrow pursuit of revenue maximization is deleterious, other sources of policy failure are in play. Delaying, reducing, or inefficiently distorting the use of bandwidth is economically harmful, whether due to misguided efforts to pump up bids or otherwise. Auctions are an important step forward. But there are miles to go before the U.S. arrives at a reliably pro-consumer spectrum policy.

---

[100] There important instances in which the right of first appropriation is a more efficient rights assignment tool. These extend to radio spectrum. See Dean Lueck, *The Rule of First Appropriation and the Design of the Law*, 38 JOURNAL OF LAW & ECONOMICS 393 (Oct. 1995).

[101] Hazlett (2008a).

[102] Hazlett & Muñoz (2009).

APPENDIX 1. FCC WIRELESS LICENSE AUCTIONS

No.	Auction Name	Auction Date	Length (Days)	Licenses Sold	Total Revenue (Net Bids - $)	Total MHz	Price per MHz-Pop
1	Nationwide Narrowband PCS	7/25/1994 - 7/29/1994	5	10	650,306,674	0.7875	3.158716
2	Interactive Video & Data Services	7/28/1994 - 7/29/1994	2	594	213,892,375	1	0.81816
3	Regional Narrowband PCS	10/26/1994 - 11/8/1994	9	130	392,706,797	0.45	10.68398
4	Broadband PCS A & B	12/5/1994 - 3/13/1995	60	99	7,721,184,171	60	0.487617
5	Broadband PCS C	12/18/1995 - 5/6/1996	83	493	10,071,708,842	30	1.260233
6	Multipoint/Multichannel Distr.Services	11/13/1995 - 3/28/1996	75	493	216,239,603	78	0.886594
7	900 MHz Specialized Mobile Radio	12/5/1995 - 4/15/1996	79	1020	204,267,144	10	0.077401
8	Direct Broadcast Satellite 110°	1/24/1996 - 1/25/1996	1.5	1	682,500,000	N/a	N/a
9	Direct Broadcast Satellite 148°	1/25/1996 - 1/26/1996	1.5	1	52,295,000	500	0.000393
10	Broadband PCS C (Re-auction)	7/3/1996 - 7/16/1996	8	18	904,607,467	30	0.11319
11	Broadband PCS D, E, F	8/29/1996 - 1/14/1997	85	1472(a)	2,517,439,565	30	0.312032
12	Cellular Unserved	1/13/1997 - 1/21/1997	6	14	1,842,533	N/a	N/a
14	Wireless Communications Service	4/15/1997 - 4/25/1997	9	126(b)	13,638,940	30	0.001691
15	Digital Audio Radio Service	4/1/1997 - 4/2/1997	2	2	173,234,888	25	0.025767
16	800 MHz Specialized Mobile Radio	10/28/1997 - 12/8/1997	27	524	96,232,060	10	0.035783
17	Local Multipoint Distribution System	2/18/1998 - 3/25/1998	26	864	578,663,029	1300	0.00164
18	220 MHz	9/15/1998 - 10/22/1998	26	693	21,650,301	N/a	N/a
20	VHF Public Coast	12/3/1998 - 12/14/1998	8	26(c)	7,459,200	0.05	0.549709
21	Location and Monitoring Service	2/23/1999 - 3/5/1999	9	289	3,438,294	14	0.000897
22	Block Broadband PCS C, D, E, F	3/23/1999 - 4/15/1999	17	302(d)	412,840,945	50	0.030153
23	LMDS Re-auction	4/27/1999 - 5/12/1999	12	161	45,064,450	1300	0.000127
24	220 MHz	6/8/1999 - 6-30-1999	17	222	1,924,950	1.55	0.004535
25	Closed Broadcast	9/28/1999 - 10/8/1999	9	115	57,820,350	N/a	N/a
27	Broadcast Auction	10/6/1999 - 10/8/1999	3	1	172,250	0.2	0.003145
26	929 & 931 MHz Paging Service	2/24/2000 - 3/2/2000	6	985	4,122,500	2	0.007324
28	Broadcast Auction	3/21/2000 - 3/24/2000	4	2	1,210,000	12	0.000358
30	39 GHz	4/12/2000 - 5/8/2000	19	2173	410,649,085	1400	0.001042
80	Blanco Texas Broadcast	7/12/2000 - 7/14/2000	3	1	18,798,000	N/a	N/a
33	Upper 700 MHz Guard Bands	9/6/2000 - 9/21/2000	12	96	519,892,575	6	0.307896
34	800 MHz SMR General Category	8/16/2000 - 9/1/2000	13	1030	319,451,810	1293.8	0.000877
36	800 MHz SMR Lower 80 Channels	11/1/2000 - 12/5/2000	22	2800	28,978,385	4	4.37
35	C & F Block Broadband PCS	12/12/2000 - 1/26/2001	24	422	16,857,046,150	70	0.845567
38	Upper 700 MHz Guard Bands (2001)	2/13/2001 - 2/21/2001	6	8	20,961,500	6	0.012267
39	VHF Public Coast Location Monitoring	6/6/2001 - 6/13/2001	6	217	1,144,755	14.05	0.000286
40	Paging	10/30/2001 - 12/5/2001	24	5323	12,897,127	2.12	0.021361
41	Narrowband PCS	10/3/2001 - 10/16/2001	8	317	8,285,036	1.8625	0.015619
42	Multiple Address Systems Spectrum	11/14/2001 - 11/27/2001	8	878(e)	1,202,725	0.825	0.005119
43	Mult-Radio Service	1/10/2002 - 1/17/2002	6	27(f)	1,548,225	30.5	0.000176
82	New Analog Television Stations	2/5/2002 - 2/13/2002	5	4	5,025,250	24	0.000726
44	Lower 700 MHz Band (2002)	8/27/2002 - 9/18/2002	16	484	88,651,630	18	0.017079
45	Cellular RSA	5/29/2002 - 6/4/2002	5	3	15,871,000	N/a	N/a
32	New AM Broadcast Stations	12/10/2002 - 12/12/2002	3	3	1,520,375	0.03	0.175744
46	1670-1675 MHz Nationwide License	4/30/2003	1	1	12,628,000	5	0.008685
48	Lower and Upper Paging Bands	5/13/2003 - 5/28/2003	11	2832	2,445,608	N/a	N/a

49	Lower 700 MHz Band (2003)	5/28/2003 - 6/13/2003	13	251	56,815,960	18	0.010854
54	Closed Broadcast (2003)	7/23/2003 - 7/29/2003	5	4	4,657,600	N/a	N/a
50	Narrowband PCS (2003)	9/24/2003 - 9/29/2003	4	48	428,709	0.6625	0.002225
51	Regional Narrowband (PCS) (2003)	9/24/2003 - 9/25/2003	2	5	134,250	0.125	0.003693
52	Direct Broadcast Satellite Service	7/14/2004	1	3	12,200,000	N/a	N/a
53	Multichannel Video Distribution & Data	1/14/2004 - 1/27/2004	9	192	118,721,835	96000	4.21E-06
55	900 MHz Specialized Mobile Radio	2/11/2004 - 2/25/2004	10	55	4,861,020	5	0.003311
56	24 GHz Service	7/28/2004	1	7	216,050	400	1.84E-06
57	Automated Maritime Telecom. System	9/15/2004	1	10	1,057,365	2	0.0018
37	FM Broadcast	11/3/2004 - 11/23/2004	14	258	147,876,075	51.6	0.009759
58	Broadband PCS (re-auction)	1/26/2005 - 2/15/2005	15	217	2,043,230,450	120	0.057444
59	Multiple Address Systems Spectrum	4/26/2005 - 5/18/2005	17	2223	3,865,515	0.7	0.01863
60	Lower 700 MHz Band	7/20/2005 - 7/26/2005	5	5	305,155	12	8.58E-05
61	Automated Maritime Telecom. System	8/3/2005 - 8/17/2005	11	10	7,094,350	2	0.011967
81	Low Power Television (LPTV)	9/14/2005 - 9/26/2005	9	90	834,600	540	5.21E-06
63	Multichannel Video Distribution & Data	12/7/2005	1	22	133,160	11000	4.08E-08
62	FM Broadcast (2006)	1/12/2006 - 1/31/2006	13	163	54,259,600	32.6	0.005559
64	Full Power TV Construction Permits	3/15/2006 - 3/20/2006	4	10	23,367,850	60	0.001301
65	800 MHz Air-Ground Radiotelephone	5/10/2006 - 6/2/2006	15	2	38,339,000	N/a	N/a
66	Advanced Wireless Services (AWS-1)	8/9/2006 - 9/18/2006	28	1087	13,700,267,150	90	0.508437
68	FM Broadcast (1/2007)	1/10/2007 - 1/17/2007	5	9	3,264,250	1.8	0.006012
69	1.4 GHz Bands	2/7/2007 - 3/8/2007	21	64	123,599,000	8	0.051223
70	FM Broadcast (3/2007)	3/7/2007 - 3/26/2007	14	111	21,301,175	22.2	0.003181
71	Broadband PCS (2007)	5/16/2007 - 5/21/2007	4	33	13,932,150	120	0.000385
72	220 MHz	6/20/2007 - 6/26/2007	5	76	185,416	0.25	0.002459
73	700 MHz Band	1/24/2008 - 3/18/2008	38	1090(g)	18,957,582,150	52	1.199004
77	Closed Cellular Unserved	6/17/2008	1	1	25,002	N/A	N/a
78	AWS-1 & Broadband PCS	8/13/2008 - 8/20/2008	6	53	21,276,850	165	0.000424
85	LPTV & TV Translator Digital Channels	11/5/2008 - 11/10/2008	4	30	134,725	180	2.46E-06

	Average auction length		**14.49**				
	Average Price per MHz-pop						**0.231747**
	Total Licenses			**27,484**			
	Total Winning Bids				**77,998,345,602**		
	Total Revenue Collected				**52,621,436,577**		
	Uncollected Revenue				**25,376,909,025**		
	Percent of High Bids Uncollected	**32.54**					