Center for American Progress

The Failure of FCC Spectrum Auctions

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Progressive Ideas for a Strong, Just, and Free America

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Executive Summary

The Federal Communications Commission's auctioning of spectrum licenses is a failure. The auctions have been subject to collusion and manipulation by big business, and as a result have failed to meet legislative guidelines. Until the FCC can demonstrate that it can conduct auctions in the public interest, Congress should halt the ongoing plans to auction licenses to the public spectrum.

In 1993 Congress gave the Commission authority to use competitive bidding to choose from among two or more mutually exclusive applications for an initial license. Prior to this the Commission mainly relied upon comparative hearings and lotteries to select a licensee from a pool of mutually exclusive applicants for a license. In the Balanced Budget Act of 1997, Congress extended and expanded the FCC's auction authority.

Congress set multiple goals for spectrum auctions, as the Congressional Budget Office pointed out:

> *In designing auctions for spectrum licenses, the FCC is required by law to meet multiple goals and not focus simply on maximizing receipts. Those goals include ensuring efficient use of the spectrum, promoting economic opportunity and competition, avoiding excessive concentration of licenses, preventing the unjust enrichment of any party, and fostering the rapid deployment of new services, as well as recovering for the public a portion of the value of the spectrum.*[1]

According to a rigorous economic analysis of the last ten years of FCC auctions by Dr. Gregory Rose, an expert in game theory, the FCC has failed to meet many of the congressional goals.

Efficiency and Maximizing Receipts

Despite legislative direction not to focus on maximizing receipts, proponents of FCC spectrum auctions suggest the competitive bidding structure is justified because it is both economically efficient and revenue maximizing. Detailed analysis of the 58 auctions thus far completed shows that the claim regarding maximizing receipts is false and the claim of efficiency is at best an illusion.

The Commercial Spectrum Enhancement Act requires the Government Accountability Office (GAO) to examine the FCC's commercial spectrum licensing process.[2] In addressing this requirement GAO conducted a literature review, organized limited "stakeholder" panels, and generally glossed over areas of disagreement.[3] The GAO relies on and repeats the FCC assertion that the auction of licenses for spectrum use is successful for two main reasons: 1) auctions are more efficient than either comparative hearings or lotteries, and 2) auctions raise revenue.

By efficient the FCC and the GAO seem to mean that auctions take into account market price where lotteries and comparative hearings do not, and that they are less of an administrative burden.[4] As Rose demonstrates, however, the FCC spectrum auctions are fraught with price distortions both as a result of FCC mispricing and tacit manipulation in the bidding process. The notion that an administrative process that is clearly flawed is justified because it is speedy cannot be supported.

The second rationale advanced by GAO and the FCC that the competitive bidding process contributes additional dollars into the U.S. Treasury is true, but that does not mean that the additional dollars are commensurate with the value of the spectrum. In a highly influential 1995 column, former Nixon aide and *New York Times* columnist William Safire expressed alarm over the federal budget deficit, and the solution he saw to this looming crisis was spectrum auctions.

> *Based only on current uses, which are primitive, the market value of the VHF, UHF, cellular, broadband and narrowband spectrum ranges around $120 billion.*
>
> *But in the near future, your television set will combine with your computers and telephone and fax machine into a single unit you can hang on the wall or fold up in your pocket. That's soon – possibly in the next Presidential term.*
>
> *I've seen not-for-attribution estimates that the market value of the digitized spectrum in that onrushing era will be – hold your breath – a half-trillion dollars, give or take a hundred billion.*[5]

While the federal budget projected a surplus at the end of the Clinton Administration, the budget deficit has ballooned again. Assuming Safire wrote this with some basis, FCC spectrum auctions have not come close to the half-a-trillion dollars desperately needed now to close the budget deficit again. Revenue from spectrum auctions so far is in the $45 billion range and the Congressional Budget Office and the Bush White House guesstimate that after a slight dip in 2008 auctions will raise perhaps another $6-10 billion through 2015. At a time when the revenue is badly needed, we have not come close to receiving a fair market value for the spectrum licenses auctioned thus far.

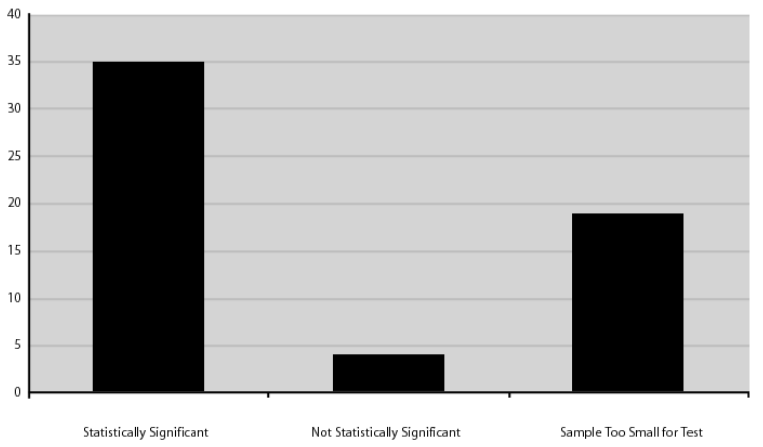
According to Rose, there is evidence that considerably less revenue has been raised than might otherwise have been the case. Large-scale mispricing by the FCC has resulted in failure to raise expected revenue or allocate licenses in over 36 percent of auctions. Further reduction of potential revenue results from the ability of bidders to adopt manipulative strategies of tacit collusion or preemptive bidding. Both of these strategies result in the auctioning of licenses at significantly lower prices to the manipulating bidders than to those who do not employ these strategies. Collusion does not generally result in a fair auction where the winning bids are commensurate with the value of auctioned item. Furthermore, significant amounts of revenue have been generated by a handful of auctions, an artifact both of genuinely different valuations for different bandwidths and of the way in which FCC rules determine qualifying bidders.

Imagine Christie's selling a million-dollar Picasso to a wealthy collector for one hundred dollars but claiming success because it was an easy and quick sale and the money is in the bank. As Dr. Rose notes, if a private auction house did as poor a job as the FCC in returning value to the sellers, that auction house would be out of business.

A Chance for Entrepreneurs?

The legislator perhaps most responsible for pushing through the 1996 Telecommunications Act was former Senator Larry Pressler. Pressler argued: "We have a responsibility to stand up to special interests and to auction off those portions of the spectrum that will provide new uses and will provide billions of dollars for the taxpayers of this country." [6] While we cannot be absolutely certain who Senator Pressler was referring to by the term "special interests," a substantial portion of the public record suggests that many members of Congress were very concerned to avoid the concentration of licenses and to provide opportunities to small entrepreneurs.

# of Auctions in Which There Is a Statistically Significant Difference in the Average Number of Licenses Assigned to the Top Five Bidders and the Bottom Five Bidders



* There are thirty-five auctions in which the difference is significant at alpha < .001, one auction in which the difference is significant at alpha < .01, and one auction in which the difference is significant at alpha < .05. In 19 auctions there was too small a sample.

Even the rosy GAO report notes that "some industry stakeholders we interviewed stated that auctions limit participation to large companies," yet GAO has not conducted an analysis of this issue. Dr. Rose's careful analysis of the auctions reveals a significant skew of auction outcomes have favored a small subset of bidders – and those bidders are not small entrepreneurs. There is a tendency for some bidders to prevail in multiple auctions, and there has been a measurable increase in the market power of large media corporations. Furthermore, the FCC procedure of simultaneous, multi-stage auctions over multiple items is subject to manipulation by tacit collusion among bidders, avoidance of head-to-head competition by the best capitalized and most successful bidders, and preemptive bidding strategies. This results in the wealthy bidders winning valuable rights to spectrum at significantly lower prices than other bidders.

The bar graph above shows the number of auctions in which the difference in average number of licenses obtained by the top five bidders and the bottom five bidders is statistically significant:[7]

A Chance for Women and Minorities?

Finally, while Congress specifically mandated that the FCC use spectrum auctions to increase economic opportunity for small businesses, women and minorities, there is no evidence that these auctions have significantly increased opportunity for any of these "designated entities." An independent study funded by the FCC indicates that "minority and women applicants were less likely to win at least one license than were non-minority applicants [and] Minorities and women qualified for auctions at significantly lower rates than non-minorities."[8]

Measured across all wireless auctions through 1999, minority and women applicants were less likely to win at least one license than were non-minority applicants. Indeed, studies commissioned by the FCC itself point to the failure of small businesses, women and minorities to qualify and to successfully participate in spectrum auctions.

The fact that barriers continue to exist limiting the participation of women and minorities has not been resolved by the FCC. Indeed, as a problem in need of solution, this goal has simply been forgotten.

Concerned that "sham buyers" were taking unfair advantage of the designated entity (DE) rules, the Commission changed its auction rules in April 2006 by "eliminating the payoff for this 'flipping' of licenses," according to Commissioner Michael Copps.[9] Still, the new rules do not prohibit DEs from having "material relationships" with larger corporations nor did they even address the problem of limited minority ownership or deployment of advanced services to minority communities. In addition the new auction rules don't address the threat of big company retaliation against smaller firms that might compete in subsequent auctions.

Three Strikes

The FCC does not know how to conduct auctions in accordance with clear legislative goals. Congress should put an end to this.

In sacrificing the public interest in pursuit of hypothetical market efficiencies and greater revenue, we have arrived at the worst of both worlds: FCC spectrum auctions neither serve the public interest nor realize the promised economic efficiencies and revenue maximization touted by their advocates. As Congress contemplates releasing the so-called analog spectrum to FCC auctioning, it should demand a demonstration that the FCC can stop the collusion, achieve fair market value, and overcome the barriers experienced by women and minorities. In short, until the FCC can conduct auctions in the public interest it should stop distributing public property.

Introduction[1]

As a result of authorization by Congress in the Omnibus Budget Reconciliation Act of 1993, since 1994 the Federal Communications Commission (FCC) has conducted 58 auctions of licenses for electromagnetic spectrum. Based in part on the FCC's initial experiences with such auctions, the Balanced Budget Act of 1997 mandated the use of auctions to resolve mutually exclusive applicants for initial licenses in all but a handful of exempted categories.[2] As the Congressional Budget Office points out,

> *In designing auctions for spectrum licenses, the FCC is required by law to meet multiple goals and not focus simply on maximizing receipts. Those goals include ensuring efficient use of the spectrum, promoting economic opportunity and competition, avoiding excessive concentration of licenses, preventing the unjust enrichment of any party, and fostering the rapid deployment of new services, as well as recovering for the public a portion of the value of the spectrum.*[3]

The adoption of auction for assignment of spectrum licenses to applicants was primarily justified on the grounds that auctions produce more efficient outcomes in terms of competition, rational exploitation of complementarities, availability of technologies to the public, and revenue maximization.

The following analysis demonstrates that the FCC auctions of licenses to use the spectrum do not meet the requirements established by Congress. They do not ensure "efficient use of the spectrum," and rather than promote "economic opportunity and competition" they have resulted in an "excessive concentration of licenses." Moreover, there is little evidence that this process has fostered the "rapid deployment of new services." And while there has been some recovery of "a portion of the value of the spectrum," it is not at all certain that auctions return to the Treasury a value close to their worth. This paper will examine each of these points in turn.

Background

Prior to the approval of spectrum auctions, the FCC assigned spectrum through comparative hearings in which the merits of two or more competitors for a single license were evaluated and a decision to allocate to one of them was made on the basis of how well an applicant made efficient use of spectrum and met the demands of the "public interest." Although the determination of the public interest was not clearly defined, it remained the more important criterion. The comparative hearing method involved three rounds of agency decision-making: before an FCC administrative law judge, the Review Board, and the Commissioners themselves, plus the possibility of review by the Court of Appeals. Lotteries were also used to allocate the first cellular telephone service licenses, although lotteries led to speculation in spectrum and resale, requiring new rule-making and extensive dispute resolution and frequently resulting in profoundly inefficient outcomes. Even today the majority of bandwidth is still assigned under comparative hearing decisions, although gradually the auction process is being applied to more and more bandwidth.

Before discussing the extent to which spectrum auctions have met the criteria which were used to justify their adoption, it is useful to briefly review how FCC spectrum auctions are conducted and what has been auctioned. FCC spectrum auctions are designed to be what are called Standard English Auctions, i.e., simultaneous, multi-round auctions in which all licenses are available for bidding in each round.[4]

Roughly four to six months prior to each auction the FCC initiates a series of steps designed to inform the public of the availability of the spectrum to be auctioned and the procedures which the auction will follow and to provide education to potential and actual bidders to familiarize them with the auction process. The FCC also obtains the refundable deposit which is used by a bidder to purchase bidding units required to bid in the auction. Before an auction begins the FCC designates a reserve price for each license, i.e., the price below which the license will not be auctioned. Failure of bidders to meet the reserve price results in FCC retention of the license unless the FCC waives the reserve price during the auction. Reserve prices have been a particularly troublesome point for the FCC, resulting in large numbers of licenses which remain in FCC hands after completion of an auction because no bidder met the reserve price. As we shall see below, this suggests that the FCC reserve price system significantly misprices such licenses.

The auctions are conducted electronically using a secure system. The duration of a round is established by the FCC prior to commencement of the auction, and at the conclusion of each round the results are announced, giving the bidders information about the value attached to each license by the other bidders. Bidding continues until there is a round in which no further bids are submitted. In some cases the FCC authorizes what is known as "package bidding," i.e., the ability of bidders to bid on groups of licenses as well as individual licenses, usually in cases in which the FCC recognizes complementarities among the licenses which affect the value of the licenses as a group. For example, in the case of auction 5 (Broadband PCS C Block),_the filing date for bidders was November 6, 1995; the pre-auction seminar was held on November 29, 1995. Upfront payments were due by December 1, 1995. Two hundred and twenty-five bidders qualified for the auction, bidding on 493 licenses, each authorizing service on frequency block C on 30MHz of bandwidth; this auction was designed for small business owners to compete. This auction was completed in 184 rounds over 83 days from December 18, 1995 to May 6, 1996, with bidders able to bid on licenses in each round until a round in which there were no further bids. Two bidders later defaulted on 18 licenses.

Economic Efficiency: Indices of Market Competition in FCC Spectrum Auctions

Promotion of competition is frequently touted as a principal benefit arising from the use of auctions to assign electromagnetic spectrum. Competition in these cases can be conceptualized in two ways: do the outcomes produced by the auction system enhance competition within the telecommunications industry generally[5] and does the auction process itself significantly exhibit the signs of real competition among bidders? On close examination of the actual data from spectrum auctions conducted by the FCC since 1994, claims for either outcome or process competition seem largely unfounded.

There are several ways to evaluate the degree to which FCC spectrum auctions enhance or diminish competition in the telecommunications industry. Of principal concern is the extent to which such auctions occasion market concentration on a scale which erects significant

barriers to entry and permits the exercise of market power to shape price. This is all the more important because of the tendency for the telecommunications industry to exhibit high levels of concentration historically. This paper proposes to look at four such measures: the percent of bidders in any auction acquiring 50 percent or more of auction items versus the percent of bidders acquiring any auction items; the mean number of licenses/permits acquired by the top five bidders versus the mean number of licenses/permits acquired by the remaining bidders; a chi-square test of the difference between the observed mean number of licenses acquired by the top five bidders and the expected mean number of licenses acquired by the top five bidders under conditions of perfect competition; and the Hirschman-Herfindahl Index of market concentration. Table 1 presents the results of these measures.

The outcomes of FCC spectrum auctions show a high degree of skew toward acquisition of 50% or more of auction items by a relatively small number of bidders. In only 15.52%[6] of auctions did a small subset of bidders fail to acquire at least 50% of items auctioned. The more competitive outcome of 50% of bidders acquiring 50% or more of auctioned items occurred in only 5.17% of auctions. Much more troubling is the evidence that very small subsets of bidders tended to acquire numbers of licenses/permits totally out of proportion to competitive expectations: 1-10% of bidders acquired 50% or more of licenses/permits in 43.10% of auctions, 11-20% of bidders acquired 50% or more of licenses/permits in 27.59% of auctions, 21-30% of bidders in 6.90% of auctions, and 31-40% of bidders in 1.72% of auctions. The mean percentage of bidders acquiring 50% or more of auction items over all FCC spectrum auctions was 11.26%. In other words, barely more than 10% of bidders were routinely able to acquire 50% or more of the available licenses/permits. Examining the situation in terms of the percentage of bidders who acquired any auction items is somewhat more promising. In only 12.07% of auctions did all bidders acquire at least one license/permit. However, in 53.45% of auctions between 51% and 100% of bidders acquired at least one item. This still leaves 46.55% of auctions in which 50% or less of bidders acquired at least one item. On average 58.19% of bidders acquired at least one license/permit. This comparison allows us to establish one pattern across FCC spectrum auctions: they tend to be dominated by a small subset of bidders who acquire a majority of auction items while other bidders typically obtain only a handful of licenses/permits, if that. This finding is supported by analysis of the mean number of auction items obtained by the top five bidders in comparison to the mean number of auction items obtained by the remaining bidders.

In the 38 auctions analysis of the mean number of auction items obtained by the top five bidders in comparison to the mean number of auction items obtained by the remaining bidders is appropriate.[7] The mean number of auction items obtained by the top five bidders reinforces the impression of a high degree of skew toward such bidders: in 24.64% of such auctions the top five bidders obtained an average of more than 100 licenses/permits each, in 2.57% 81-100, in 7.69% 61-80, in 7.69% 41-60, in 17.95%, 21-40, and in 38.46% of auctions 1-20 items. On average the top five bidders received a mean of 85.82 auction items. Examination of the mean number of auction items obtained by the remaining bidders reveals a similarly staggering skew: in 30.77% of such auctions the remaining bidders acquired on average less than one license/permit, in 51.28% between 1 and 5 auction items, in 7.69% 6-10 items, in 5.13% 11-15 items, in 2.565% 16-20 items, and in 2.565% 21-25 auction items. On average the remaining bidders received a mean of 3.43 auction items. These findings are consistent with the existence of a strong skew biasing auction outcomes in favor of a small subset of bidders.

TABLE 1

Auction Number	Type	# of Licenses at Auction & Actually Asgn'd.	Number of Bidders	% of Bidders Acquiring 50% or More of Auction Items	% of Bidders Acquiring Any Auction Items	Mean Number of Licenses Acquired by Top 5 Bidders	Mean Number of Licenses Acquired by Remaining Bidders	Chi-Square Test of Difference Between Observed and Expected/PC	a	HHI
1	PCS Narrowband Nation	10	29	10.35	20.69	2.00	0.0417	7.23	<.01	2700
2	IVDS	594	289	12.11	61.59	17.20	1.7887	108.66	<.001	1130
3	PCS Narrowband Region	130	28	10.71	32.14	4.60	0.3043	12.78	<.001	1377
4	PCS A&B Block	99	30	10.00	60.00	14.80	1.0000	44.43	<.001	1537
5	PCS C Block	493	255	5.10	34.90	30.20	1.4250	413.42	<.001	348
6	MDS	493	155	3.87	43.23	54.40	1.6533	1189.52	<.001	714
7	900 MHz SMR	1020	123	3.25	24.39	126.00	2.3155	1670.75	<.001	940
8	DBS (110W)	1	3	0.00	33.33	-	-	-	-	10000
9	DBS(148W)	1	2	0.00	50.00	-	-	-	-	10000
10	PCS Block C Reauction	18	32	9.38	21.88	3.20	0.0741	12.37	<.001	2531
11	PCS D,E, F Block	1479(1472)	153	4.58	81.70	132.80	5.4595	1243.79	<.001	542
12	Cellular Unserved	14	22	13.64	45.45	1.80	1.0000	0.64	NS	1429
14	WCS	126	24	12.50	70.83	17.40	2.0000	28.12	<.001	1289
15	DARS	4	4	0.00	50.00	-	-	-	-	5000
16	800 MHz SMR	525(524)	62	1.61	22.58	102.00	0.2456	1033.14	<.001	8232
17	LMDS	986(864)	139	6.47	78.82	79.40	3.4900	861.66	<.001	709
18	220 MHz	908(693)	54	7.41	81.48	90.20	4.9400	466.41	<.001	1227
20	VHF Public Coast	42(26)	8	12.50	50.00	5.20	0.0000	1.17	NS	3846
21	LMS	528(239)	5	20.00	80.00	-	-	-	-	6661
22	PCS	347(302)	57	5.97	85.07	34.20	2.0791	195.60	<.001	866
23	LMDS	161	90	6.67	44.44	15.20	1.0000	100.54	<.001	686
24	220 MHz	225(222)	18	11.11	88.89	35.40	3.4615	43.14	<.001	1846
25	Closed Broadcast	115	242	13.60	37.60	4.00	0.4008	26.15	<.001	152
26	929 and 931 Paging	2499(985)	81	9.88	96.30	78.00	7.8289	356.49	<.001	490
27	Broadcast	1	3	0.00	33.33	-	-	-	-	10000
28	Broadcast	2	4	0.00	50.00	-	-	-	-	5000
30	39 GHz	2175	35	8.57	82.86	346.00	14.6667	1298.32	<.001	2302
32	AM Broadcast Stations	3	5	0.00	60.00	-	-	-	-	6000
33	Upper 700 MHz Guard	96	15	13.33	60.00	18.40	0.4000	22.50	<.001	2938
34	800 MHz SMR General	1053(1030)	26	3.85	53.85	199.40	1.5714	668.90	<.001	6146
35	PCS C&F Block	422	87	3.45	40.23	56.00	1.7317	538.37	<.001	1315
36	800MHz SMR Lower	2800	28	3.60	78.60	546.60	2.9130	1994.52	<.001	8497
37	FM Broadcast	288(258)	456	2.63	24.12	18.60	0.3659	574.82	<.001	408
38	Upper 700 MHz Guard	8	5	0.00	60.00	-	-	-	-	3438
39	Public Coast & LMS	257(217)	7	28.57	100.00	42.20	3.0000	4.04	<.05	3103
40	Paging	15514(5323)	193	8.29	94.30	312.00	20.0200	2933.04	<.001	312

TABLE 1

Auction Number	Type	# of Licenses at Auction & Actually Asgn'd.	Number of Bidders	% of Bidders Acquiring 50% or More of Auction Items	% of Bidders Acquiring Any Auction Items	Mean Number of Licenses Acquired by Top 5 Bidders	Mean Number of Licenses Acquired by Remaining Bidders	Chi-Square Test of Difference Between Observed and Expected/PC	a	HHI
41	Narrowband PCS	365(317)	9	11.11	55.56	63.40	0.0000	22.54	<.001	5163
42	Multiple Address Sys	5104(878)	13	7.69	100.00	156.00	12.2500	115.87	<.001	3412
43	Multi-Radio Service	27	7	14.29	42.86	5.40	0.0000	0.61	NS	5007
44	Lower 700 MHz band	740(484)	125	8.00	81.60	36.80	2.5000	280.02	<.001	478
45	Cellular RSA	3	7	0.00	43.00	-	-	-	-	3333
46	1670-1675 MHz Band	1	2	50.00	50.00	-	-	-	-	10000
48	Lower & Upper Paging	10202(2832)	104	10.58	92.31	191.20	18.9495	987.37	<.001	370
49	Lower 700 MHz Band	256(251)	56	3.57	62.50	32.60	1.7254	176.39	<.001	1667
50	Narrowband PCS	48	4	25.00	75.00	-	-	-	-	7734
51	Narrowband PCS	5	2	50.00	50.00	-	-	-	-	10000
52	Direct Broadcast Satellite	3	2	50.00	100.00	-	-	-	-	5556
53	MVDDS	214(192)	14	14.29	71.43	35.40	1.6667	34.31	<.001	2123
54	Closed Broadcast	4	6	16.67	33.33	-	-	-	-	6250
55	900 MHz SMR	55	17	5.88	29.41	11.00	0.0000	18.64	<.001	7078
56	24 GHz	880(7)	3	33.33	66.66	-	-	-	-	4286
57	AMTS	20(10)	4	25.00	100.00	-	-	-	-	3600
58	Broadband PCS	242(217)	35	11.42	68.57	27.40	2.6667	72.49	<.001	988
59	Multiple Address Systems	4226(2223)	31	6.45	83.87	398.40	8.8846	1488.31	<.001	2583
60	Lower 700 MHz Band	5	5	0.00	43.00	-	-	-	-	3600
61	AMTS	10	7	28.57	57.14	2.00	0.0000	0.24	NS	3000
80	Blanco, Texas Broadcast	1	11	9.09	9.09	-	-	-	-	10000
82	New Analog Television	4	11	9.09	27.27	-	-	-	-	3750

It remains to determine if this strong skew in favor of a small subset of bidders is statistically significant. The chi-square test of goodness of fit measures the degree to which an observed distribution differs from a theoretical distribution.[8] In this case the observed distribution is the number of auction items obtained by the top five bidders; the distribution is the distribution of auction items obtained by the top five bidders under the assumption of perfect competition, i.e., equiprobability of success in an environment of perfect information and symmetrical resources. In 84.62% of auctions to which this test was applied the difference was significant at $a < .001$, in 2.56% of auctions it was significant at $a < .01$, and in 2.56% of auctions it was significant at $a < .05$. In 10.26% of auctions to which this test was applied no significant difference was found. Thus, in the overwhelming majority of FCC spectrum auction outcomes there has been a statistically significant bias in favor of a relatively small subset of bidders.

Even with this statistically significant bias it is still possible that the degree of market concentration produced by this bias is less than apparent because of the possibility of relatively large sets of bidders who are at least marginally successful in obtaining auction items. In order to explore this hypothesis let us assume that each auction amounts to a market in that particular bandwidth of spectrum, i.e., that the distribution of licenses over the successful bidders indicates market share.[9]

The Hirschman-Herfindahl Index (HHI) is a common measure of market concentration which is particularly sensitive to the number of actors in the market and can, therefore, indicate where the breadth of the distribution of licenses/permits mitigates the concentration effects of the already observed biasing skew.[10] The HHI is also useful in this case because it allows examination of auctions in which the number of auction items or the number of bidders was too small for a significant chi-square test. The U.S. Department of Justice uses the HHI in evaluating antitrust actions, regarding an HHI < 1,000 as indicating a competitive market, an HHI ≤ 1,000 to 1,800 as indicative of a moderately concentrated market, and an HHI >1,800 as indicative of a highly concentrated market. In 24.14% of FCC spectrum auctions HHI < 1,000 occurs; in 13.79% of auctions an HHI between 1,000 and 1,800 occurs, while in 62.07% of these auctions an HHI > 1,800 occurs. This suggests that while the breadth of distribution of licenses in roughly 24% of auctions reduces the danger of market concentration, in nearly 76% of FCC spectrum auctions moderate to high concentration still occurs.

TABLE 2	Low HHI	Mod. HHI	High HHI
Low Skew Bias	-	2.94	7.89
Moderate Skew Bias	-	-	5.26
High Skew Bias	36.84	15.79	31.58

Table 2 summarizes the findings by relating the degree of skew biasing outcomes in favor of the five top bidders to the HHI for each auction. While it is clear that the breadth of distribution of licenses/permits in some auctions mitigates some of the market concentration effect even in the presence of significant skew favoring the top five bidders, it remains disturbing that 37 of 38 auctions examined score high in market concentration on at least one of the indices. This suggests strongly that outcome competition is not characteristic of FCC spectrum auctions and these auctions fail to enhance competition general in the telecommunications industry.

TABLE 3 Firm	# Licenses Assigned	Auction
Nextel Spectrum Acquisition Corp.	3437	33, 34, 36, 38, 43
WinStar Wireless Fiber Corp.	931	30
CloudNine Wireless, LLC	843	59
Jamestown Manufacturing Corporation	698	40
Advanced Metering Data Systems, LLC	652	59
TeleBEEPER of New Mexico, INC	624	40, 42, 43, 48,
MilkyWay Communications, LLC	476	42
Nextel License Acquisition Corp.	475	16
Intelligent Trans. & Monitoring Wireless	357	59, 61
Advanced Radio Telecom Corp.	352	30
Schuylkill Mobile Fone, Inc.	333	40, 48
Agri-Valley Communications, Inc.	270	48
Space Data Spectrum Holdings, LLC	247	41, 50, 51
AT&T Wireless PCS Inc.	243	4, 11
Baker Creek Communications, L.P.	232	17
Intek License Acquisition Corp.	232	18, 24
Communications Equipment, Inc.	231	40
Progeny LMS, LLC	230	21
Geotek Communications, Inc.	181	7
Southern Communications Services, Inc	179	34, 36
FCI 900, Inc.	177	7
Hyperion Communications Long Haul, LP	177	30
Microwave Data Systems Inc.	168	42
Scott C. MacIntyre	161	40, 41, 50, 55
SprintCom, Inc.	160	11
Metrocall USA, Inc.	145	26
Zephyr Wireless, L.L.C.	140	30
Cellco Partnership d/b/a Verizon Wireless	139	35, 58
New York State Electric & Gas Corporation	138	48
Warren C. Havens	137	20, 21, 24
Jeffrey Scott Cofsky dba Texas License	136	48
Consultants	130	30
Atlantis Bidding Corp.	126	18
Net Radio Group Communications, LLC	126	7
Paging Network of America, Inc.	109	11
OPCSE-Galloway Consortium	101	41
Allegheny Communications, Inc.	100	11
Western PCS BTA I Corp.	93	6
Heartland Wireless Communications, Inc.	89	49
Aloha Partners II, L.P.	84	39
Helen Wong-Armijo	83	7
RAM Mobile Data USA, LP	82	16, 34, 36
Nevada Wireless, LLC	82	16, 59
Southern Company Services, Inc.	80	39
Telesaurus Holdings GB, LLC	79	44, 60
Aloha Partners, L.P.	79	35
Salmon PCS, LLC	78	26
Vodafone AirTouch Licenses, LLC	73	11
AllTel Mobile Communications, Inc.	68	59
Great River Energy	68	18
Nextel 220 License Acquisition Corp.	64	22
ABC Wireless, L.L.C.	63	7
Fleet Talk, INC.	63	26
WWC Paging Corp.	60	53
MDS Operations, Inc.	58	22, 35
Leap Wireless International, Inc.	56	6

A troubling additional factor in evaluating the extent to which FCC spectrum auctions contribute to market concentration in the telecommunications industry is the large number of firms which have prevailed as top five bidders in more than one auction: 31 firms have prevailed in at least two auctions, nine in at least three auctions, and five in at least four auctions. Various firms associated with Nextel prevailed among the top five bidders in seven auctions, amassing a total of 3,980 licenses. This suggests that the factors cited in the analysis above militate to advantage a number of firms across multiple auctions as well as in individual auctions. Table 3 lists the top 100 bidders in terms of number of licenses/permits acquired in FCC spectrum auctions.

Economic Efficiency: Strategic Manipulation in FCC Spectrum Auctions

Does the auction process itself significantly exhibit the signs of real competition among bidders? There are several ways of addressing this question. Table 4 provides two indices which are helpful in providing an answer. One of the factors which militates for oligopolistic rather than perfect competition in real-world markets is initial capitalization asymmetries. Actors who come to the market with fewer resources to invest, who are, therefore, more vulnerable to the vicissitudes of market fluctuation and to intimidation by stronger market actors, are significantly disadvantaged in their ability to compete. This situation also obtains in FCC spectrum auctions – some bidders come to the auction with hugely more resources to deploy strategically in pursuing acquisition of blocks of licenses than do others. However, there is a problem in that the majority of bidders are firms which are not publicly traded and it is difficult to obtain accurate information on their capitalization. It is for that reason necessary to develop a proxy variable which indirectly measures differences in initial capitalization.

TABLE 3 Firm	# Licenses Assigned	Auction
American Telecaasting Development, Inc.	56	33, 34, 36, 38, 43
NextWave Personal Communications, Inc.	53	30
MAP Paging Co., Inc.	51	59
Eclipse Communications Corp.	51	40
Intek License Acquisition Corp.	51	59
Trompex Corp.	48	40, 42, 43, 48,
MilkyWay Broadband, LLC	46	42
ACI 900, Inc.	46	16
DTV Norwich, LLC	44	59, 61
Alaska Native Wireless, LLC	44	30
Cavalier Group, LLC	43	40, 48
DCR PCS, Inc.	42	48
NEXTBAND Communications, LLC	41	41, 50, 51
Paging Systems, Inc.	40	4, 11
Telephone & Two-Way, Inc.	40	17
WNP Communications, Inc.	39	18, 24
Repeater Ntwk Spectrum Acquisition, Inc.	38	40
College Creek Broadcasting, Inc.	38	21
Preferred Acquisitions Inc.	37	7
220 MHz Bidding Consortium	37	34, 36
SOUTH.COM LLC	37	7
Vista PCS, LLC	36	30
Cook Inlet/VS GSM VII PCS, LLC	36	42
Wireless One, Inc.	34	40, 41, 50, 55
OPCS Three, LLC	34	11
Pegasus Guard Band, LLC	33	26
Motient Communications Co.	32	30
Actel Corp.	32	35, 58
CAI Wireless Systems, Inc.	32	48
PCS Partners, LP	31	20, 21, 24
Cloudnine Communications, Inc.	31	48
Coloma Wireless, Inc.	31	30
LIN Television Corp.	28	18
Cook Inlet/VoiceStream PCS LLC	28	7
PCTV Gold, Inc.	28	11
WirelessCo, LP	26	41
220 MHz Auction Group	24	11
Bruce E. Fox	24	6
Vulcan Spectrum, LLC	23	49
Bell South Wireless Cable, Inc.	22	39
Cook Inlet/VS GSM V PCS, LLC	21	7
A.R.C., Inc.	21	16, 34, 36
Access Spectrum, LLC	21	16, 59
Edge Mobile, LLC	21	39
Radioactive, LLC		44, 60
		35
		26

As stated earlier, bidders in FCC spectrum auctions are required to place a refundable deposit with the FCC which determines the number of bids the bidder may place in the auction. While there are factors other than just initial capitalization which affect the amount a bidder may deposit, i.e., the bidder may be interested in acquiring only a small subset of the available spectrum, this deposit primarily reflects the resources the bidder brings to the auction and can strategically deploy in the bidding process. Thus comparison of the mean upfront deposit of the five most successful bidders to that of the five least successful bidders in an auction provides a proxy measure of the range of initial capitalization asymmetry in the auction. There are 33 FCC spectrum auctions in which the number of bidders and items at auction are sufficiently large to permit reliable analysis of the ratio of the mean upfront deposit of the top/bottom five bidders in the auction. Only in one auction (auction 59, Multiple Address Systems) does this ratio favor the bottom end of the distribution. In the remaining 32 (96.97%) relevant auctions the ratio decidedly favors the bidders who prove to be most successful in the auction. The ratio ranges from 1.26 to 186.76; obviously the larger the ratio, the greater the putative initial capitalization asymmetries in a given auction. The mean ratio for all 33 auctions is 46:64. A Student's paired, two-tailed t-test of the difference of the means of the two distributions underlying the ratio was significant at a=.0167, which strongly implies that a very real difference is measured by the ratio. That significant initial capitalization asymmetries exist between bidders in these auctions and that the asymmetries significantly favor those bidders who eventually prevail is evidence that competition within the auctions is negatively affected by these facts. As will be shown below, such asymmetries make available strategies – particularly preemptive bidding – to a subset of bidders which can systematically reduce the price at which auction items are acquired.

TABLE 4 Auction Number	Type	# of Licenses at Auction & Actually Asgn'd.	Number of Bidders	% of Licenses Acquired in 1st Round	Ratio of Mean Upfront Deposit Top/Bottom 5 Bidders
1	PCS Narrowband Nation	10	29	0.00	NDA
2	IVDS	594	289	0.00	NDA
3	PCS Narrowband Region	130	28	0.00	1.26
4	PCS A&B Block	99	30	0.00	1.69
5	PCS C Block	493	255	0.00	28.55
6	MDS	493	155	0.00	92.60
7	900 MHz SMR	1020	123	3.63	112.21
8	DBS (110W)	1	3	0.00	-
9	DBS(148W)	1	2	0.00	-
10	PCS Block C Reauction	18	32	0.00	7.79
11	PCS D,E, F Block	1479(1472)	153	1.70	25.02
12	Cellular Unserved	14	22	28.57	3.00
14	WCS	126	24	31.75	81.19
15	DARS	4	2	0.00	-
16	800 MHz SMR	525(524)	62	5.73	16.19
17	LMDS	986(864)	139	11.26	34.00
18	220 MHz	908(693)	54	18.61	81.90
20	VHF Public Coast	42(26)	8	0.00	-
21	LMS	528(239)	5	0.00	-
22	PCS	347(302)	57	10.93	33.12
23	LMDS	161	90	0.00	6.65
24	220 MHz	225(222)	18	0.00	9.40
25	Closed Broadcast	115	242	13.04	10.94
26	929 and 931 Paging	2499(985)	81	70.46	48.51
27	Broadcast	1	3	0.00	-
28	Broadcast	2	4	0.00	-
30	39 GHz	2175	35	28.87	4.16
32	AM Broadcast Stations	3	5	0.00	-
33	Upper 700 MHz Guard	96	15	0.00	2.62
34	800 MHz SMR General	1053(1030)	26	6.70	62.15
35	PCS C&F Block	422	87	0.00	185.39
36	800MHz SMR Lower	2800	28	60.82	51.20
37	FM Broadcast	288(258)	456	1.55	16.76
38	Upper 700 MHz Guard	8	5	25.00	-
39	Public Coast & LMS	257(217)	7	52.53	-
40	Paging	15514(5323)	193	36.88	186.76
41	Narrowband PCS	365(317)	9	2.21	-
42	Multiple Address Sys	5104(878)	13	64.24	24.76
43	Multi-Radio Service	27	7	0.00	-
44	Lower 700 MHz band	740(484)	125	24.38	28.26
45	Cellular RSA	3	7	0.00	-
46	1670-1675 MHz Band	1	2	0.00	-
48	Lower & Upper Paging	10202(2832)	104	50.46	28.72
49	Lower 700 MHz Band	256(251)	56	2.79	183.57
50	Narrowband PCS	48	4	2.08	-
51	Narrowband PCS	5	2	0.00	-
52	Direct Broadcast Satellite	3	2	0.00	-
53	MVDDS	214(192)	14	8.33	25.47
54	Closed Broadcast	4	6	0.00	-
55	900 MHz SMR	55	17	7.27	6.38
56	24 GHz	880(7)	3	57.14	-
57	AMTS	20(10)	4	90.00	-
58	Broadband PCS	242(217)	35	6.45	136.98
59	Multiple Address Systems	4226(2223)	31	35.36	0.41
60	Lower 700 MHz Band	5	5	0.00	-
61	AMTS	10	7	0.00	-
80	Blanco, Texas Broadcast	1	11	0.00	-
82	New Analog Television	4	11	0.00	1.42

Another index of competition within an auction is the percentage of licenses/permits which are acquired by a bid in the first round of the auction. Acquisition of an auction item with a bid placed in the first round signals either the absence of a competitor to bid for the item or a preemptively high bidder which intimidates other bidders from entering competition for the item. In 29 (50%) of the 58 FCC spectrum auctions which have been conducted to date, auction items were acquired with a bid placed in the first round. The percentage of auction items acquired in this fashion ranges from 1.55% (auction 27, FM Broadcast) to 90% (auction 57, AMTS) with a mean of 13.08% over all the auctions. This is particularly disturbing evidence of non-competitive behavior in FCC spectrum auctions, particularly when contextualized with what we shall see below is an alarmingly high number of licenses at auction which never receive any bid whatsoever.

Collusive behavior is yet another indicator of non-competitive dynamics at work in the FCC spectrum auctions. In 2000 Peter Cramton and Jesse Schwartz examined such behavior in auction 11, the PCS D, E, F Block auction.[11] The problem which they identified was that fact that

> *[d]uring the DEF auction (the Personal Communications Service (PCS) auction for broadband frequency blocks D, E, and F) the FCC and the Department of Justice observed that some bidders signaled each other with code bids. A code bid uses the trailing digits of the bid to tell other bidders on which licenses to bid or not bid. Since bids were often in the millions of dollars, yet were specified in dollars, bidders a negligible cost could use the last three digits — the trailing digits — to specify a market number. Often, a bidder (the sender) would use these code bids as retaliation against another bidder (the receiver) who was bidding on a license desired by the sender. The sender would raise the price on some license the receiver wanted, and use the trailing digits to tell the receiver on which market to cease bidding. Although the trailing digits are useful in making clear which market the receiver is to avoid, retaliating bids without the trailing digits can also send a clear message.*[12]

They also found that

> *six of the 153 bidders in the DEF auction regularly signaled using code bids or retaliating bids. These bidders won 476 of the 1,479 licenses for sale in the auction, or about 40% of the available spectrum in terms of population covered. These signaling bidders paid about the same as other bidders for the F-block licenses, but on the D and E blocks, the signaling bidders paid $2.50/person, where as nonsignaling bidders paid $4.34/person. Moreover, when we control for market characteristics, we find that bidders that used code bids or retaliating bids paid significantly less for not only the D and E licenses, but also for the F licenses. We take this as evidence that the bid signaling strategies were effective at keeping prices low on the collection of licenses desired by the signaling bidders.*
>
> *Further, there was a tendency for bidders to avoid bidding against AT&T, a large bidder with a reputation for retaliation. Bidders frequently bid substantially more for an identical license, rather than bid on the cheaper license held by AT&T.*[13]

To anyone who has followed the game theoretic literature analyzing behavior in Standard English Auctions, the findings of Cramton and Schwartz should be unsurprising. The work of Engelbrecht-Wiggins and Kahn[14] and of Brusco and Lopomo[15] has demonstrated that the auction design adopted by FCC spectrum auctions is particularly susceptible to tacitly collusive manipulation by bidders through signaling. Both studies have identified the existence of equilibria in which bidders can coordinate assignment of auction items at relatively low prices in auctions characterized by bidding on distinct units in sequential rounds. These equilibria are achieved through retaliation against bidders who refuse to cooperate in the assignment arrangement. It is important to note that the collusion achieved here is tacit rather than explicit. There is no need to assume prior communication and negotiation of the assignment arrangement. All that is required for tacit collusion is that the bidders recognize that self-interest is served by signaling which items they desire and which they are willing to forgo through retaliation against bids which threaten their acquisition of the items they desire. This is similar to the dynamic in oligopolistic markets in which the major actors achieve production and price equilibria which can be negotiated and enforced by the threat of punishment. It is also important to note that the dynamics of FCC spectrum auctions are somewhat more complicated than those of the game theoretic models developed by Engelbrecht-Wiggins and Kahn and of Brusco and Lopomo, since they are characterized by initial capitalization and complimentarity asymmetries as well as by the heterogeneity of auction items. In particular this implies both that collusive strategies will be somewhat more difficult to identify and that better capitalized bidders with substantial complementarities in their license acquisitions are more likely to be effective in utilizing a tacitly collusive strategy.

A related tacitly collusive strategy available in FCC spectrum auctions is the avoidance of head-to-head competition over licenses by the dominant bidders. This bidding strategy is suggested by a nearly uniform tendency observed since antitrust actions and deregulation in land-line telephony, cellular services, cable television, and broadband services, namely, avoidance of direct competition between major actors which might negatively affect profit and market share. To be sure, some of this phenomenon arises from the existence of complementarities arising from the technological need for geographical contiguity. However, analysis of two randomly selected FCC spectrum auctions in which head-to-head competition between the dominant bidders was examined while controlling for geographic contiguity (auction 43 – Multi-Radio Service – and auction 25 – Closed Broadcast) showed significant patterns of avoidance.

It should be kept in mind that the entire auction process is a series of reiterative games and in such games the likelihood of bidders learning ways in which to manipulate the bidding process is relatively high. In some cases, e.g., the classic Prisoner's Dilemma, iterative learning creates the possibility of Pareto-optimal equilibria, but such games are structurally different from the games which model auctions (i.e., the Pareto-optimal outcome necessitates collusion in the form of tacit agreement) and there is neither good theoretical nor empirical reason to believe that the sequential equilibria of auction games are impervious to anti-competitive collusive bidder manipulation.[16]

Economic Efficiency: An Abject Failure of Competition in FCC Spectrum Auctions

Analysis of market power relations arising from outcomes in FCC spectrum auctions reveals the claim of increased economic efficiency in the form of increased competition put forward to justify adoption of the auction policy is simply not supported by the evidence. The evidence of a strong skew in favor of a small subset of bidders, the confirmatory evidence of the HHIs associated with each auction, and the number of bidders who have prevailed in multiple auctions all point inevitably to FCC spectrum auctions as engines for the production of market competition in the telecommunications industry. The examination of strategic manipulation in FCC spectrum auctions has disclosed evidence of behaviors which systematically limit competition in the auction process. It is no exaggeration to suggest that oligopolistic competition characterizes most FCC spectrum auctions based on the evidence of capitalization asymmetries, first round acquisitions, and tacitly collusive bidding strategies. Bluntly, a substantial element of the rationale on which Congress based authorization of these auctions was little more than blue smoke and mirrors.

Revenue Maximization and FCC Spectrum Auctions

It is one of the ironies of the way in which FCC spectrum auctions evolved that the economic theorists who designed them tend to emphasize justifications on grounds of economic rationality or efficient allocation of resources and to denigrate claims that revenue maximization was ever a major factor in their thinking, while the politicians who authorized them have embraced revenue maximization with a vengeance. As Eli Noam acutely observed,

> *The underlying objective for the auction "game" is to raise revenues for government. This is usually denied quite heatedly, and other considerations are cited, such as moving spectrum to the users valuing it most, etc. But the political fact is that auctions were finally approved, after years of opposition to them by powerful Congressional barons and the broadcast industry, as a measure to reduce the budget deficit and avoiding spending cuts and tax increases. Allocating spectrum resources efficiently was a secondary goal in the political process. The maximizing function may have been constrained in several ways, such as by rules against monopoly control and in favor of diversity. But these additional policy considerations were only the fig leaf on the main reason, raising money for the empty coffers of the Federal Government. The rest is merely technique. Conceived in the original sin of budget politics rather than communications policy, spectrum auctions are doomed to serve as collection tools first and allocation mechanism second.*[17]

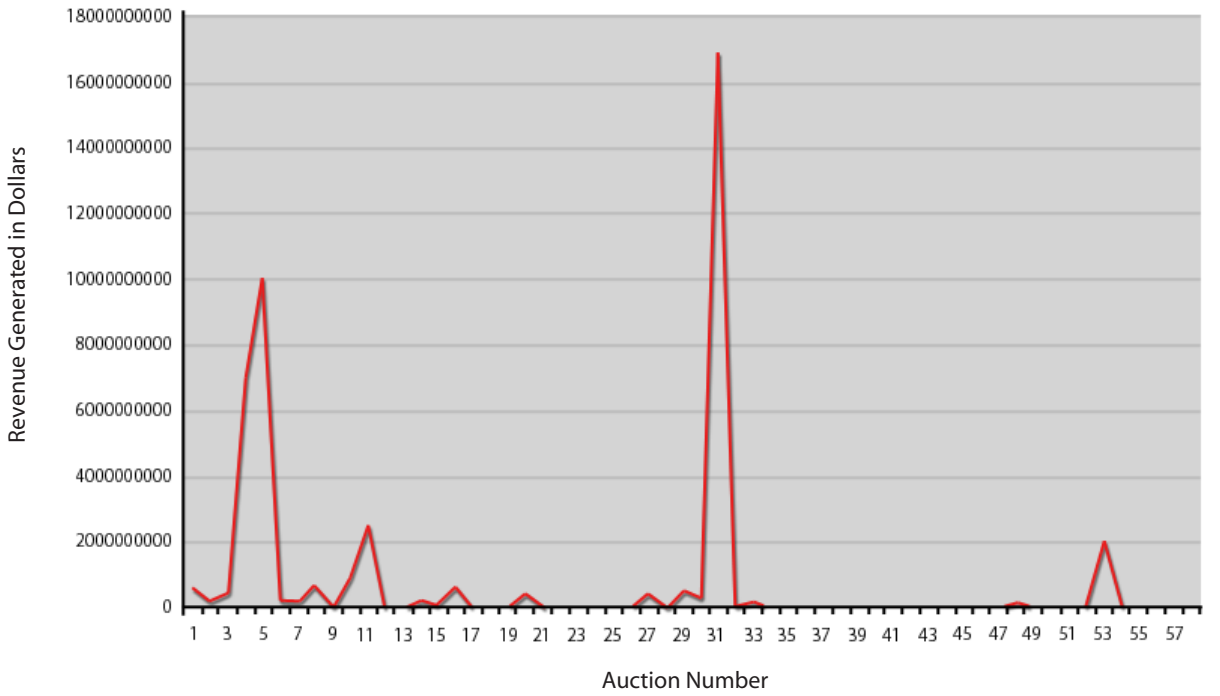
On the face of it, FCC spectrum auctions have been veritable engines for making money for the federal government. To date FCC spectrum auctions have raised slightly over $45 billion. Table 5 provides the revenue per auction and the revenue per license for each auction. However, the total revenue figure is somewhat misleading. When you examine the auction revenue figures over time, it becomes apparent that a small number have generated most of the revenue, while the others generate vastly less revenue. Table 6 provides a graphic illustrating this. This pattern in revenue-generation is an artifact both of genuinely different valuations for different bandwidths and of the way in which FCC rules shape the qualifying bidder set.

TABLE 5

Auction Number	Type	# of Licenses at Auction & Actually Asgn'd.	Number of Bidders	% of Licenses Held by FCC at End of Auction	Revenue in $	Mean Revenue Per License
1	PCS Narrowband Nation	10	29	0.00	617,006,674.00	61,700,667.40
2	IVDS	594	289	0.00	213,892,375.00	360,088.17
3	PCS Narrowband Region	130	28	0.00	392,706,797.00	3,020,821.52
4	PCS A&B Block	99	30	0.00	7,019,403,797.00	70,903,068.66
5	PCS C Block	493	255	0.00	10,071,708,842.00	20,429,429.70
6	MDS	493	155	0.00	216,239,603.00	438,619.88
7	900 MHz SMR	1020	123	0.00	204,267,144.00	200,261.91
8	DBS (110W)	1	3	0.00	682,500,000.00	682,500,000.00
9	DBS(148W)	1	2	0.00	52,295,000.00	52,295,000.00
10	PCS Block C Reauction	18	32	0.00	904,607,467.00	50,255,970.39
11	PCS D,E, F Block	1479(1472)	153	0.47	2,517,439,565.00	1,702,122.76
12	Cellular Unserved	14	22	0.00	1,842,533.00	131,609.50
14	WCS	126	24	0.00	13,638,940.00	108,245.56
15	DARS	4	2	0.00	173,234,888.00	43,308,722.00
16	800 MHz SMR	525(524)	62	0.19	96,232,060.00	183,299.16
17	LMDS	986(864)	139	12.37	578,663,029.00	586,879.34
18	220 MHz	908(693)	54	23.68	21,650,301.00	23,843.94
20	VHF Public Coast	42(26)	8	38.10	7,459,200.00	177,600.00
21	LMS	528(239)	5	45.27	3,438,294.00	6,511.92
22	PCS	347(302)	57	12.97	412,840,945.00	1,189,743.36
23	LMDS	161	90	0.00	45,064,450.00	279,903.42
24	220 MHz	225(222)	18	1.33	1,924,950.00	8,555.33
25	Closed Broadcast	115	242	0.00	57,820,350.00	502,785.65
26	929 and 931 Paging	2499(985)	81	60.58	4,122,500.00	1,649.66
27	Broadcast	1	3	0.00	172,250.00	172,250.00
28	Broadcast	2	4	0.00	1,210,000.00	605,000.00
30	39 GHz	2175	35	0.00	410,649,085.00	188,804.18
32	AM Broadcast Stations	3	5	0.00	1,520,375.00	506,791.67
33	Upper 700 MHz Guard	96	15	0.00	519,892,575.00	5,415,547.66
34	800 MHz SMR General	1053(1030)	26	2.18	319,451,810.00	303,661.42
35	PCS C&F Block	422	87	0.00	16,857,046,150.00	39,945,606.99
36	800MHz SMR Lower	2800	28	0.00	28,978,385.00	10,349.42
37	FM Broadcast	288(258)	456	10.42	147,876,075.00	513,458.59
38	Upper 700 MHz Guard	8	5	0.00	20,961,500.00	2,620,187.50
39	Public Coast & LMS	257(217)	7	0.00	1,144,755.00	4,454.30
40	Paging	15514(5323)	193	65.70	12,897,127.00	2,338.98
41	Narrowband PCS	365(317)	9	13.15	8,285,036.00	22,698.73
42	Multiple Address Sys	5104(878)	13	82.80	1,202,725.00	235.64
43	Multi-Radio Service	27	7	0.00	1,548,225.00	57,341.67
44	Lower 700 MHz band	740(484)	125	34.59	88,651,630.00	183,164.52
45	Cellular RSA	3	7	0.00	15,871,000.00	5,290,333.33
46	1670-1675 MHz Band	1	2	0.00	12,628,000.00	12,628,000.00
48	Lower & Upper Paging	10202(2832)	104	72.24	2,445,608.00	239.72
49	Lower 700 MHz Band	256(251)	56	2.00	56,815,960.00	221,937.34
50	Narrowband PCS	48	4	0.00	428,709.00	8,931.44
51	Narrowband PCS	5	2	0.00	134,250.00	26,850.00
52	Direct Broadcast Satellite	3	2	0.00	12,200,000.00	4,066,666.67
53	MVDDS	214(192)	14	10.28	118,721,835.00	554,774.93
54	Closed Broadcast	4	6	0.00	4,657,600.00	1,164,400.00
55	900 MHz SMR	55	17	0.00	4,861,020.00	88,382.18
56	24 GHz	880(7)	3	99.20	216,050.00	245.51
57	AMTS	20(10)	4	50.00	1,057,365.00	52,868.25
58	Broadband PCS	242(217)	35	10.33	2,043,230,450.00	8,443,101.03
59	Multiple Address Systems	4226(2223)	31	47.40	3,865,515.00	914.70
60	Lower 700 MHz Band	5	5	0.00	305,155.00	61,031.00
61	AMTS	10	7	0.00	7,094,350.00	709,435.00
80	Blanco, Texas Broadcast	1	11	0.00	18,798,000.00	18,798,000.00
82	New Analog Television	4	11	0.00	5,025,250.00	1,256,312.50

TABLE 6

FCC Spectrum Auction Revenue, 1994 - 2005



There is disturbing evidence that, despite the considerable revenue raised by the spectrum auctions, the FCC is not maximizing revenue because it is significantly misestimating bidder valuation of bandwidth in the reserve prices it sets. As explained above, the FCC sets a reserve price for licenses or packages put to auction. In 21 of 58 auctions (36.21%) licenses have been at auction but were retained by the FCC because no bidder met the reserve price. In most cases no bid whatsoever was placed on these licenses. This phenomenon ranges from .47% of licenses in auction 11 (PCS D, E, & F Blocks) to 99.20% of licenses in auction 56 (24 GHz); it averages 11.99% of licenses over all 58 auctions. In the majority of auctions the FCC has revised reserve prices downward even on licenses for which bids were received, so it is a much more significant indicator of mispricing that so many licenses received no bids at all.

Another indication of spectrum auctions' failure to maximize revenue is the way in which bidding strategies available only to a subset of bidders can systematically reduce price. Preemptive bidding is a strategy whereby a bidder offers a price for an auction item which is sufficiently large that it deters other bidders from competing for the item. This strategy is more readily available to bidders which are more heavily capitalized. For the purposes of this paper, a preemptive bid is defined operationally as a prevailing bid of at least half the mean final bid of the auction which successfully deters further bidding. Four auctions (14, 11, 30, and 48) were analyzed for the presence and consequences of preemptive bidding. Two types of such bidding were observed. Type 1 consists of a large initial bid which deters other bidders from ever bidding on the item. Type 2 consists of a large bid in later rounds which deters other bidders from further bidding. As Table 7 illustrates, bidders using type 1 preemptive bids in auction 14 obtained items on average at only 7.30% of the mean price paid by bidders who did not use this strategy. The success of this strategy was smaller in the other four auctions, but still significant: in auction 11 type 1 preemptive bidders obtained items on average at 46.19% of the mean price paid by

TABLE 7	Auction 14 (WCS)	Auction 11 (PCS D, E, F Block)	Auction 30 (39 GHz)	Auction 48 (Lower and Upper Paging Bands)
Preemptive Type 1	0.02358610	0.13645532	0.03566729	0.00094472
Preemptive Type 2	0.02629208	-	-	-
Other Than Preemptive Type 1	0.32288502	0.29543305	0.08612346	0.00175541
Other than Preemptive	0.38155176	-	-	-

bidders who did not use the strategy, in auction 30 at 41.41%, and in auction 48 at 53.82%. In auction 14 bidders using type 2 preemptive bids obtained items on average at 6.89% of the mean price paid by bidders who did not use the strategy. The perviousness of FCC spectrum auctions to strategic behavior available to bidders better capitalized than other bidders – a function of initial capitalization asymmetries – results in depression of price in favor of those bidders and adversely affects revenue.

Affirmative Inaction: Designated Entities, Small Business, Women, and Minorities

In authorizing the FCC to conduct spectrum auctions Congress mandated that the agency use such auctions to increase economic opportunity for small businesses, women and minorities. An examination of the FCC's own auction data suggests that this mandate has been willfully ignored by the agency.

The most data is available for participation of small businesses in spectrum auctions. Of the 22,649 licenses and permits awarded by auction 1,435 have been acquired by firms meeting the small business criteria of the FCC – 6.34% of all licenses. The FCC has worked its way though an increasingly arcane set of rules regarding small business participation in spectrum auctions, none of which appear to have had a substantial effect in increasing the success of small business bidders. In auction 5 – PCS C Block – the "entrepreneur" category was embraced:

> *To qualify as an entrepreneur, bidders must have gross revenues of less than $125 million in each of the last two years and total assets of less than $500 million at the time the FCC Form 175 application was filed).*[18]

The "bidding credit" strategy also emerged:

> *Qualifying applicants in Auction No. 5 were eligible for a bidding credit on C block licenses that represents the amount by which a bidder's winning bids are discounted. The size of the bidding credit depends on the average gross revenues for the preceding three years of the bidder, as provided in 47 C.F,R. § Section 24.709 and §24.720(b).*
>
> *• A bidder with average gross revenues not exceeding $40 million for the preceding three years received a 25 percent discount on its winning bids for C.*
>
> *The definitions of very small business and small business (or a consortium of very small or small businesses; including calculation of average gross revenues) are set forth in 47 C.F.R. § 24.720(b).*

Winning bidders of C licenses should note that transfer and assignment restrictions and unjust enrichment provisions apply to winning bidders that use bidding credits and subsequently assign or transfer control of their licenses to an entity not qualifying for the same levels of bidding credits.[19]

Eighty-nine small business "entrepreneurs" acquired 493 licenses in this auction. The same rules were followed in auction 10 – the PCS C Block Reauction – in which seven small businesses acquired 18 licenses. In auction 11 – PCS D, E, and F Blocks – the entrepreneur rule was in place and the "bidding credit" strategy was modified:

Size of an F-block bidding credit depends on the annual gross revenues of the bidder and its affiliates, as averaged over the preceding three years.

** A bidder with gross annual revenues of not more than $15 million receives a 25 percent discount on its winning bids, and*

** A bidder with gross annual revenues of not more than $40 million receives a 15 percent discount on its winning bids.*[20]

Ninety-three small businesses acquired 598 licenses. In auction 14 – WCS – the "bidding credit" strategy was continued. Eight small businesses acquired 32 licenses in this auction. In auction 22 – PCS – the "bidding credit" strategy was again adopted. Forty-eight small businesses under this definition acquired 277 licenses. In auction 25 – Closed Broadcast – the "bidding credit" strategy was amended to reward new entrants:

In the "Closed" Broadcast Auction, the bidding credit depends upon the number of ownership interests in other media of mass communications that are attributable to the bidder-entity and its attributable interest-holders. (See PN DA99-1346 (pdf) for more information)

• A 35 percent bidding credit will be given to a winning bidder if it, and/or any individual or entity with an attributable interest in the winning bidder has no attributable interest in any other media of mass communications, as defined in 47 C.F.R. § 73.5008; and,

• A 25 percent bidding credit will be given to a winning bidder if it, and/or any individual or entity with an attributable interest in the winning bidder has an attributable interests in no more than three media of mass communications, as defined in 47 C.F.R. § 73.5008; and,

• No bidding credit will be given if any of the commonly owned mass media facilities would serve the same area as the proposed broadcast or secondary broadcast station, as defined in 47 C.F.R. § 73.5007, or if the winning bidder, and/or any individual or entity with an attributable interest in the winning bidder, have attributable interests in more than three mass media facilities.

However, attributable interests held by a winning bidder in existing low power television, television translator or FM translator facilities will not be counted among the bidders' other mass media facilities.[21]

Neither winner of the two licenses in this auction was a new entrant. In auctions 27 and 28 – both Broadcast – the same rule prevailed, but no new entrant did. In no other auctions does the FCC report that small businesses or new entrants acquired licenses and inconsistencies in data categories and lacuna in reporting by the FCC make it impossible to determine whether this is an artifact of the failure of small businesses to prevail or inept data reporting by the FCC. At the very least it implies that FCC ceased to care whether this information was made available to the public or not.

The extent to which any measures undertaken by the FCC under its designated entities program have ameliorated discrimination against women and minorities is virtually impossible to determine, although the FCC's own studies suggest that not much has happened. The FCC does not make easily available data on the gender and ethnicity of auction bidders; indeed, only one bidder in all the auctions is identifiably female by name – Helen Wong-Armijo. A Congressional Budget Office study, based on data provided to it by the FCC, indicates that in the Regional Narrowband, Broadband PCS C Block, Broadband PCS D, E & F Block, Specialized Mobile Ratio, and Multipoint Distribution Service auctions women and minorities did not do especially well except in the PCS C Block auction. Table 8 contains the relevant data. Studies commissioned by the FCC

TABLE 8

Auction Number	Type	# of Licenses at Auction	Number of Bidders	Number (%) of Licenses Acquired by Minority-Owned Businesses	Number (%) of Licenses Acquired by Women-Owned Businesses
3	PCS Narrowband Region	130	28	6(4.00)	5(3.85)
5	PCS C Block	493	255	150(30.43)	95(19.27)
6	MDS	493	155	10(2.03)	35(2.35)
7	900 MHz SMR	1020	123	31(3.04)	19(1.86)
11	PCS D,E, F Block	1479(1472)	153	70(4.76)	50(3.40)

and reporting on spectrum auctions through 2000 are depressingly acute on the continued presence of real discrimination. In terms of auction utilization they report:

Measured across all wireless auctions through 1999, minority and women applicants were less likely to win at least one license than were non-minority applicants.... Minorities and women qualified for auctions at significantly lower rates than non-minorities. The reasons for this result are not entirely clear, suggesting this is an area for future research...[22]

One might think that historical patterns of income, credit, and entry discrimination and the FCC's collusion in their perpetuation simply never occurred to the analysts as an explanation, if another study commissioned by the FCC at the same time had not made the point directly:

Minorities and women repeatedly report encountering discrimination in their efforts to obtain capital to finance their broadcast and wireless businesses, discrimination in securing advertising on their stations, and discrimination by members of their communities and members of the communications industry.... Small telecommunications businesses generally, and those owned by women

and minorities in particular, report that the market consolidation permitted by the relaxation of the FCC's ownership rules has created nearly insurmountable obstacles to those seeking to enter, or even survive as a small player, in the broadcast industry.... Minority-owned firms report that the repeal of the former tax certificate program - which, from 1978 until its repeal in 1995, provided tax incentives to encourage firms to sell broadcast licenses to minority-owned firms - has had a severe negative impact on their ability to obtain new stations; and Interviewees believed that EEO enforcement has been uneven over the past fifty years. This reported uneven enforcement coupled with industry hiring practices has hindered the ability of minorities and women to obtain the work experience that could one day assist them to become broadcasters themselves.[23]

This is, bluntly put, a continuing national scandal about which the FCC has done little or nothing.

Conclusions

Analysis of the last ten years of FCC spectrum auctions reveals that these auctions have met neither the standards nor the expectations expressed by Congress in their authorization. They do not facilitate the development of robust markets or meet the needs of the broader public interest. Instead these auctions, as they have been conducted, appear to serve the narrow interest of dominant actors in the telecommunications industry. They have systematically resulted in market concentration and the growth of the oligopolistic market power of major actors in the telecommunications industry. They have been pervious to manipulation by tacit collusion among bidders in ways which no minor amendment of the auction process could possibility remedy. Even the often made argument that FCC spectrum auctions maximize revenue fails in the face of both FCC mispricing of licenses, reflected in the large number of licenses which fail to be auctioned because no bidder meets the reserve price, and substantial evidence that strategic behaviors like preemptive bidding can guarantee better capitalized bidders licenses at consistently lower prices than their competitors.

What has principally driven the adoption of spectrum auctions by the FCC and Congress has been ideologically-libertarian economic theory, captured in simplistic models which ignore inconvenient facts. Game theory is a powerful tool for analysis of economic behavior. However, a game-theoric model is only as good as its assumptions. Assumptions about information, bidder resources, risk-acceptance and -aversion, and the structure of bidder preference all matter, because they imply things about how the real world operates. All modeling is along a continuum between analytical tractability and empirical verisimilitude: the more mathematically tractable the model is, the less it resembles the real thing being modeled. It is for this reason that social scientists frequent evaluate and refine such models through experiments to see whether an analytically tractable model captures what really matters about the thing it models. The past ten years of FCC spectrum auctions have amounted to such an experiment, and the experiment demonstrates that the models on the basis of which Congress and the FCC were persuaded to adopt spectrum auctions fail dramatically in their prediction of real-world outcomes. When tested by the actual performance of such auctions, the chasm between the outcomes predicted by theory and the outcomes observed is immense. In sacrificing the public interest in pursuit of hypothesized market efficiencies and greater revenue we have arrived at the worst of both worlds: FCC spectrum auctions neither serve the public interest nor realize the promised economic efficiencies and revenue maximization touted by their advocates.

Appendix A: An Excursus on the History of an Idea

How spectrum auctions came about reveals a fundamental problem with the relationship between economic theory and public policy. John McMillan, one of the architects of FCC spectrum auctions, candidly exposed the problem in a 1994 journal article:

> *The story of how the spectrum auction was designed is a case study in the policy application of economic theory. The major telephone companies and the government relied on the advice of theorists. Paul Milgrom, Robert Wilson, and Charles Plott were hired by Pacific Bell, Jeremy Bulow and Barry Nalebuff by Bell Atlantic, Preston McAfee by Airtouch Communications, Robert Weber by Telephone and Data Systems, Mark Isaac by the Cellular Telecommunications Industry Association, Peter Cramton by MCI, Robert Harris and Michael Kat by Nynex, Daniel Vincent by American Personal Communications, John Ledyard and David Porter by the National Telecommunications and Information Administration and the author of this article by the Federal Communications Commission (FCC).*[1]

R.H. Coase first proposed FCC spectrum auctions in 1959.[2] However, it was not until the 1980s that the seminal theoretical work was done which shaped the current design of such auctions. The FCC working paper by Kwerel and Felker in 1985 signaled official interest in the idea, which was regarded favorably by laisse-faire advocates in the Reagan administration.[3] This chain of events occasioned the flourishing of an economic theoretical literature which applied game theoretic approaches to deduction of what were thought to be ideal allocative designs. This work in turn led not only to both the harnessing of mathematical economists to the interests of potential participants in such auctions, as McMillan describes, but also to the increasing influence of such interests on the focus of theoretical research. The interaction effects of this process can be seen in virtually every aspect of FCC spectrum auctions. The decision to adopt an open bidding procedure is predicated directly on arguments from from Paul Milgrom's 1987 article on auction theory.[4] The work of Milgrom, Robert Wilson, Preston McAfee, and John McMillan materially shaped the sequential design and stopping rules of FCC spectrum auctions.[5] The FCC's designated entities program is largely predicated on Myerson's 1981 article and a 1987 article by McAfee and McMillan.[6]

A full history of the development of the auction design is outside the scope of this paper. However, what is pertinent is that a crucial nexus was established between highly theoretical work in mathematical economics and the material interests of both the FCC and potential auction participants. This should not be unacceptable in principle, but a crucial constraint on the operationalization of theory was woefully minimized.

All economic theory is a balancing act along a continuum between representation of the real world (what is often called empirical verisimilitude) and analytical tractability. Trade-offs are made in the form of tractability assumptions which permit the mathematization of model. The farther such theoretical models retreat from assumptions which reflect realities in order to achieve something which can be tractably analyzed mathematically, the more likely it is that such theory will no longer be empirically predictive with sufficient granularity to be a useful adjunct to policy. The matter is complicated further when economic theory is harnessed to and tempered by the interests of actors who stand to directly benefit from the adoption of a particular policy. This is

precisely what has happened with the theoretical literature on the basis of which spectrum auctions were sold to Congress and upon which the current spectrum auction design is predicated.

This is not to say that all economic theory is useless nor that policy should not be significantly guided by such theory – the game-theoretic work on tacitly collusive strategies in sequential auctions is compelling when potential complications arising from empirical circumstances are taken into account. It is, however, a cautionary tale for the way in which public policy predicated on abstract economic theory can falter on the shoals of gritty reality.

Endnotes

Executive Summary

[1] U.S. Government, Congressional Budget Office, *The Budget and Economic Outlook: Fiscal Years 2001-2010* (Washington, D.C., 2000), Appendix B.

[2] Commercial Spectrum Enhancement Act, Pub. L. No. 108-494, 118 Stat. 3986, Title II (2004) (codified in various sections of Title 47 of the United States Code) ("CSEA").

[3] U.S. Government Accountability Office, Report to Congressional Committees, "Strong Support for Extending FCC's Auction Authority Exists, but Little Agreement on Other Options to Improve Efficient Use of Spectrum," December 2005, GAO-06-236.

[4] Ibid, *see also* Auctioning Spectrum Rights, Evan Kwerel & Walt Stack, FCC, Feb. 20,2001. http://wireless.fcc.gov/auctions/data/papersAndStudies/aucspec.pdf

[5] William Safire, "The Greatest Auction Ever," *New York Times*, March 16, 1995

[6] Senator Larry Pressler, "FCC/SPECTRUM/PUBLIC BROADCASTING REFORM**,"** Congressional Record, s13312 (Senate - September 11, 1995).

[7] There are thirty-five auctions in which the difference is significant at alpha < .001, one auction in which the difference is significant at alpha < .01, and one auction in which the difference is significant at alpha < .05. In 19 auctions there was too small a sample.

[8] U.S. Government. Federal Communications Commission, "FCC Econometric Analysis of Potential Discrimination Utilization Ratios for Minority- and Women-Owned Companies in FCC Wireless Spectrum Auctions," December 5, 2000, http://www.fcc.gov/opportunity/meb_study/auction_utilization_study.txt. The study was prepared by Ernst and Young LLP for the FCC.

[9] In the Matter of Implementation of the Commercial Spectrum Enhancement Act and Modernization of the Commission's Competitive Bidding Rules and Procedures at http://www.fcc.gov/omd/pra/docs/3060-0600/3060-0600-06.doc, see also Copps statement at http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-06-52A3.doc

Report

[1] The research underlying this paper was made considerably more difficult by the way in which the FCC collects and organizes auction data. Random differences in result format and variable capture – apparently a consequence of there being no authoritative decision as to how data would be collected -- are rife in the FCC's databases. Information on designated entity participation is particularly difficult to retrieve. Frankly, if the evident cause for the incoherent data capture and reporting were not incompetence, one might think the cause to be fraud. There is a fundamental need for greater rigor and consistency in FCC auction results collection and reporting without which the reliability of FCC data must be questioned.

[2] These exempted categories included non-commercial education and public broadcast stations, public safety radio services, and replacement of analog television licenses with digital television licenses.

[3] U.S. Government, Congressional Budget Office, *The Budget and Economic Outlook: Fiscal Years 2001-2010* (Washington, D.C., 2000), Appendix B.

[4] The FCC departed from this auction design in 1994 for the Interactive Video and Data Service (IVDS) auction in July 1994, using an oral outcry design instead.

[5] Auctions are predicated on the bidder with the highest private value winning. This is no guarantee that bidders with the highest social value will prevail. This tension between private and social value has been resolved in FCC spectrum auctions almost entirely in favor of private value.

[6] Note that fractions are rounded in this analysis.

[7] This analysis was not performed for auctions in which fewer than five licenses/permits were at auction or in which fewer than five bidders participated.

[8] The formula for calculating the chi-square is $\sum[(O - E)^2/E]$, where O is the observed frequency and E is the expected theoretical frequency.

[9] When one controls for differences in size of population in license region by a weighting for price (high bid/population), this assumption is quite literally true because each auction allocates all of the designated bandwidth and the amount of bandwidth acquired reflects market share in that bandwidth.

[10] The formula for the HHI is $\sum s_i$, where s_i is the market share of bidder i. The Theil coefficient of inequality produces similar results for the auction data tested here.

[11] Peter Cramton and Jesse A Schwartz, "Collusive Bidding in the FCC Spectrum Auctions," *Contributions to Economic Analysis & Policy* 1:1 (2002).

[12] Ibid.

[13] Ibid.

[14] Richard Engelbrecht-Wiggans and Charles M. Kahn, "Low Revenue Equilibria in Simultaneous Auctions," Working Paper, University of Illinois, 1999.
[15] Sandro Brusco and Guiseppe Lopomo, "Collusion Via Signalling in Simultaneous Ascending Bid Auctions with Heterogeneous Objects, With and Without Complementarities," *Review of Economic Studies* 69:2 (2002), 407-436.
[16] Viz. Robert Axelrod and William D. Hamilton, "The Evolution of Cooperation". *Science* 211 (1981), 1390–1396; Robert Axelrod, *The Evolution of Cooperation* (1984) and *The Complexity of Cooperation*. (Princeton: Princeton University Press, 1997); David Kreps, Robert Wilson, Paul Milgrom, and John Roberts, "Rational Cooperation in the Finitely Repeated Prisoners' Dilemma." *Journal of Economic Theory* 27 (1982), 245–52; and Paul Milgrom, "Axelrod's The Evolution of Cooperation*." Rand Journal of Economics* 15(1984), 30–59.
[17] Eli Noam, "Spectrum Auctions: Yesterday's Heresy, Today's Orthodoxy, Tomorrow's Anachronism," *Journal of Law and Economics* (1998).
[18] http://wireless.fcc.gov/auctions/default.htm?job=auction_factsheet&id=5.
[19] Ibid.
[20] http://wireless.fcc.gov/auctions/default.htm?job=auction_factsheet&id=11.
[21] http://wireless.fcc.gov/auctions/default.htm?job=auction_factsheet&id=25.
[22] U.S. Government,- Federal Communications Commission, "FCC Econometric Analysis of Potential Discrimination Utilization Ratios for Minority- and Women-Owned Companies in FCC Wireless Spectrum Auctions," December 5, 2000, http://www.fcc.gov/opportunity/meb_study/auction_utilization_study.txt. The study was prepared by Ernst and Young LLP for the FCC.
[23] U.S. Government,- Federal Communications Commission, "Historical Study of Market Entry Barriers, Discrimination and Changes in Broadcast and Wireless Licensing: 1950 60 Present," December 2000, http://www.fcc.gov/opportunity/meb_study/historical_study.txt. The report was prepared for the FCC by the Ivy Planning Group LLC.

Appendix

[1] John McMillan, "Selling Spectrum Rights," *Journal of Economic Perspectives* (1994).
[2] R.H. Coase, "The Federal Communications Commission," *Journal of Law and Economics* 2 (1959).
[3] Evan R. Kwerel and Alex Felker, "Using Auctions to Select FCC Licenses," OPP Working Paper No. 16, FCC, May 1985.
[4] Paul Milgrom, "Auction Theory," in Truman Bewley, ed., *Advances in Economic Theory* (Cambridge: Cambridge University Press, 1987).
[5] McMillan, op. cit.
[6] R. Myerson, "Optimal Auction Design," *Mathematics of Operations Research* 6 (1981); R. Preston McAfee and John McMillan, "Auctions and Bidding," *Journal of Economic Literature* 25 (1987).

About the Authors

Gregory F. Rose received his Ph.D. in Government Economics at the University of Texas at Austin. He has taught political science, government and economics at a number of universities including the University of Texas at Austin and the University of Mississippi and has been published in a variety of academic journals on formal theory and mathematical modeling with a concentration in game theory, political theory, collective choice theory, statistics and research design, and formal modeling applications in comparative politics and international relations. He currently serves as an advisor to the public interest law group, The Media Access Project, where he has written a number of papers including: *An Economic Analysis of the Comcast/ Time Warner/Adelphia Transactions* and *Conceptual Problems in Game Theoretic Modeling of Spectrum Auctions.*

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