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Spectrum Auction Breakdown: HOW INCUMBENTS MANIPULATE FCC AUCTION RULES TO BLOCK BROADBAND COMPETITION

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> *The most obvious possible distortion is that since firms' joint profits in the telecom market are generally greater the fewer competitors there are in the market, it is worth more to any group of firms to prevent entry of an additional firm than the additional firm is willing to pay to enter. So too few firms may win spectrum, and these winners may each win too much, exactly as a "hands-off" policy to merger control will tend to create an overly concentrated industry.*
>
> —Paul Klemperer, *Auctions: Theory and Practice*, (Princeton, 2004), 112

Summary of Findings and Recommendation

Federal Communications Commission (FCC) spectrum auctions can seem arcane and technical, but in fact, auctions for exclusive licenses to use the public airwaves determine the future of American telecommunications. FCC auctions shape the competitive structure of markets and, ultimately, who controls entire industries—from broadcasting, to telephony, to wireless broadband services—that are increasingly central to U.S. productivity growth, consumer welfare, and global competitiveness. These auctions have complex rules, rules which are the subject of study by a branch of economics called game theory. And it is virtually an axiom of game theory that the rules determine who wins and who loses.

The two studies summarized in this paper comprehensively examine the FCC's 2006 Advanced Wireless Services (AWS-1) auction. They focus on two aspects of the way information was used by bidders to engage in collusive, anti-competitive, and demand-reduction behaviors. I conclude that the auction rules were manipulated to exclude new entrants to the marketplace from obtaining spectrum in favor of incumbent cable companies, wireless operators, and telephone companies which feared the competition those new entrants represented. Careful analysis of the patterns of bidding behavior in last year's AWS-1 auction leads to following conclusions:

- There was a concerted effort by major incumbents in the FCC's AWS-1 spectrum auction to target those new entrants whose entry represented a significant potential competitive threat if (1) they acquired a national AWS footprint in the AWS-1 auction or (2) they acquired a strong regional or multi-regional base from which they could acquire national footprint in future auctions.

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- The targeted new entrants were met with a tacitly-collusive strategy of blocking bidding, with coalitions of multiple major incumbents making bids for the apparent purpose of denying licenses to the new entrant rather than acquiring the licenses for themselves. A majority of the major incumbents ceased bidding on such licenses after the targeted new entrant ceased bidding.

- The strategy of blocking was successful. All but two targeted new entrants were denied any spectrum in the AWS-1 auction.

- There is evidence in the pattern of bids that the major incumbents' blocking bidding strategy may have been explicitly collusive and the incumbents were willing to pay a significant premium to block the targeted new entrants, indicated by the significantly higher mean price they paid for the spectrum they acquired (2.5 times higher) compared to other bidders.

- The principal signaling behavior identified was retaliatory bidding, which occurred in the AWS-1 auction at a slightly higher level than in the FCC's 1996-97 PCS D, E, and F Block auctions. Significant indirect demand reduction effects were observed in the AWS-1 auction, calling into question whether the auction—whatever it's impact on competition—even succeeded in maximizing revenue for the government.

Both the blocking and retaliatory bidding strategies evidenced in the AWS-1 auction limited competition, adversely affected new entrants and most likely reduced total auction revenue. Both strategies were also available only because bidders were provided with the identities of all other bidders and of the licenses on which they bid in each round. The study concludes with a recommendation that the FCC should adopt anonymous bidding rules for the 700 MHz and for future FCC spectrum auctions. Anonymous bidding remains the only auction rule that can hope to prevent the effective use of retaliatory bidding, blocking bidding and other forms of tacit collusion by incumbents and other bidders.

Introduction

The way FCC spectrum auctions are conducted is, to a certain extent, straightforward. Bidders are solicited and qualified by presenting upfront payments to cover their bidding and specifying the licenses on which they intend to bid. An auction is conducted in rounds with bidders placing bids on the licenses they seek; each bidder bids on the license he wants in up to nine standard increments specified by the FCC (bid increases of more than one increment per round are relatively rare). At the end of each round all the bidders learn who bid on which licenses and how much they bid. The auction continues until there have been three rounds in which no new bids have been made. The high bidder on each license then wins that license, which FCC jargon calls "purchased with bid" (PWB). There are also rules about minimum bidder activity during rounds, withdrawal of bids on licenses, and penalties for withdrawal. This kind of auction is a simultaneous, ascending, open-bid, auction. It is sometimes called an English auction.

As I discuss in more depth below, in 1999, two scholars did a study of the August 1996 - January 1997 FCC auction of the D, E and F Blocks of Personal Communications Services (PCS) spectrum. They found a troubling behavior called signaling, a form of tacit collusion, in that auction. The first study in this paper uses the same methodology to analyze the AWS-1 auction and finds that signaling remains a serious problem.

The form of signaling in question is termed retaliatory bidding. A bidder who wants a particular license and is challenged by another bidder can signal the fact that he is displeased by this situation by bidding on another license his challenger really wants, but he doesn't. This drives the price up on the license his challenger really wants and signals that the challenged bidder is prepared to impose costs on the challenger unless he backs off. Frequently, the challenger does back off and the bidder who used retaliatory bidding gets the license he wants at a much lower price than would have been the case if the challenger persisted. The problem is that even a small amount of retaliatory bidding can have dramatic effects. Bidders who see retaliatory bidding become reluctant to bid against retaliatory bidders for fear that they will be retaliated against. This produces what is called demand reduction: the seller receives less revenue than he would have otherwise because many bidders reduce their demand, i.e., don't go after licenses sought by retaliatory bidders, and that keeps prices low for retaliatory bidders. More troubling, this further calls into question what had been a fundamental assumption in auction theory which justified simultaneous, ascending, open-bid auctions in the first place, the Linkage Principle. The Linkage Principle holds that providing bidders with more information produces more revenue in an auction. Clearly, however, letting potential retaliatory bidders know who is bidding on which licenses permits demand reduction, since retaliatory bidding could not happen without that information. Thus, we have a clear example of a situation where the availability of some kinds of information to bidders reduces an auction's revenue.

The second study in this paper identifies another kind of anti-competitive behavior in the AWS-1: blocking bidding. With blocking bidding, a group of bidders identifies other bidders whom they wish to prevent from obtaining licenses. They then collude, either tacitly or explicitly, before the auction's anti-collusion rules take effect (i.e., before they become official, qualified bidders), to bid as a coalition against every attempt the targeted bidders make to acquire licenses. When the coalition consists of the best-financed incumbents in the auction, as it did in the AWS-1 auction, this can prevent the targeted new entrants from obtaining any spectrum at all. Specifically in the AWS-1 auction, a coalition of cable companies, wireless operators, and telephone companies was determined to prevent new entrants from obtaining a national footprint (i.e., enough licenses to obtain large enough regional or national coverage to make large-scale competition against the incumbents economically feasible). Denied sufficient spectrum for a national footprint, the new

entrants could never realize their business plans and would never deploy significant competition against the incumbents. The adverse effects of reduced competition in the marketplace for consumers are obvious. Like retaliatory bidding, blocking bidding manipulates the rules by using the information provided by the auction to identify the licenses on which potentially competitive new entrants are bidding and allows them to marshal resources to block them on those licenses.

Ultimately, as we shall see, the problem is the way information is manipulated to reduce demand and inhibit competition in FCC spectrum auctions. And the solution to this problem is anonymous bidding.

A Tale of Anonymous Bidding

Congress and the FCC authorized spectrum auctions on the basis of economic theories about competition and efficiency and a conviction that auctioning spectrum would maximize the revenue paid for use of a scarce public resource. With the accumulation of empirical evidence from actual spectrum auctions, the distance between theory and practice becomes increasingly apparent: bidders have used auction rules to engage in behaviors which hamper competition and reduce the efficiency of the resulting allocations, and which threaten the revenue maximization which auction theorists have promised. As early as 1999, Peter Cramton and Jesse Schwartz circulated a paper which identified tacitly collusive, anti-competitive behaviors on the part of bidders—code bidding and retaliatory bidding—in the PCS D, E, and F Block auction of 1996-97.[1] These signaling behaviors were used by bidders to gain a reputation for imposing costs on those who dared to bid against them and were used to limit the ability of new entrants, fearful of retaliation, to effectively compete against some established incumbents. Most importantly, such signaling behaviors led to significant demand reduction and concomitant loss of revenue. Such signaling behaviors were possible only under conditions of open bidding.[2]

On another front, the "Linkage Principle,"[3] as it has been termed by Paul Milgrom, came under increasing attack from 1999 to 2004. The "Linkage Principle" holds that auction structures which disclose more information to bidders increase auction revenue. This "principle" has been shown to be false for auctions in which multiple objects and multidimensional bidder types are present.[4] This was particularly important because the "Linkage Principle" is the principal theoretical rationale for open bidding. Both empirical and theoretical evidence emerged that open auctions – auctions in which the identities and bids of all bidders were disclosed to the rest of the bidders – could produce anti-competitive, inefficient, and revenue depressing outcomes.

Leslie Marx, the FCC's Chief Economist, resolved to do something in response to the growing mass of evidence that open-bid auctions were problematic, and in connection with the upcoming AWS-1 auction, proposed rules for anonymous bidding. The only information provided to bidders before and during the auction would be the high bid amount on each license at the end of each round; who had bid on what and who the high bidder was would be kept secret until the end of the auction. The FCC's anonymous bidding proposal was enthusiastically supported by the U.S. Department of Justice, the Federal Trade Commission, and numerous consumer organizations and public interest groups. The incumbents who were planning to bid in the AWS-1 auction launched a firestorm of criticism and an intense political campaign to prevent the adoption of anonymous bidding, including a letter to Chairman Martin threatening not to participate in the auction.[5] The threat was absurd on its face, as the ultimate participation of the incumbents proved: no one rationally expected the incumbents to refrain from bidding on

spectrum this valuable. Still, as one lobbyist for the incumbents told *Communications Daily*, "You can't go to the FCC and argue with an economist. This is a political play. These are businesses and this is of critical importance to these businesses. Economic theories be damned ... We'll be suited up and at the FCC." [6] Seldom have the incumbents been so frank.

The principal arguments assembled by the incumbents were that there was no need for the rules change and that anonymous bidding would prevent bidders from assessing appropriate complementarities as they bid to aggregate packages of spectrum in accordance with their business plans. Some smaller bidders weighed in with the argument that anonymous bidding prevented them from avoiding head-to-head bidding wars with the major incumbents. Consumer organizations and public interest groups argued that the problems of signaling and other anti-competitive behaviors were real and only anonymous bidding could resolve them. In particular, they noted that the incumbents used open bidding to identify new entrants to exclude from acquiring spectrum, that bidders who hadn't decided before the bidding began on complementarities among the licenses which they were seeking were admitting to having no bidding strategy, and that smaller bidders like rural telephone companies were seldom challenged by major incumbents for the spectrum on which they routinely bid. In the end, resolution of the matter of anonymous bidding was not a question of arguments, but of political muscle.

T-Mobile proposed a compromise: anonymous bidding would not be used in the AWS-1 auction unless the modified eligibility ratio fell below three (i.e., unless the eligibility of qualified bidders produced, on average, fewer than three bidders per license). This threshold was completely arbitrary. The modified eligibility ratio of three-to-one was simply the next highest integer above the ratio in the PCS D, E, and F Block auction which Cramton and Schwartz had studied. Signaling had taken place in that auction, so it was proposed that a ratio of three would stop the signaling. Despite the lack of evidence that this threshold would be effective, the FCC adopted the compromise.

It is interesting that the AWS-1 auction had among its qualified bidders four which never placed a bid, and seven which bid only once. Given how narrowly the modified eligibility ratio reached 3.05, if these marginal bidders had not been present, the auction would have been anonymous. This certainly suggests that the auction rules were gamed by the introduction of "qualified" bidders whose presence was solely to ensure that a modified eligibility ratio of three was achieved so that the AWS-1 auction would not be anonymous. The vigor with which several incumbents opposed anonymous bidding raises the question of whether they had any hand in arranging the participation of these "ratio pumping" bidders in the auction. At the least, the AWS-1 auction experience suggested that "compromises" which introduce artificial conditions for implementation of anonymous bidding were an invitation for the rules to be gamed.

Anonymous bidding did not occur in the AWS-1 auction, and thus it provided a test of whose claims—the incumbents' or their opponents'—were the true.

Part One: Tacit Collusion in the AWS-1 Auction – The Signaling Problem[7]

I. Signaling Behaviors Are a Threat to Revenue Maximization in FCC Auctions

A. Theoretical Evidence

Signaling represents a direct threat to revenue maximization in FCC spectrum auctions. A considerable theoretical literature exists which points to the demand reduction effects of signaling and similar tacitly collusive strategies in simultaneous, open, ascending multi-object auctions.[8] The underlying intuition is that to the extent retaliation forces competitors out of bidding for a license, the retaliating bidder obtains the license at a lower price than it would otherwise obtain, reducing revenue from the auction by reducing demand from bidders threatened by retaliation. As Brusco and Lopomo note,

> The presence of multiple objects facilitates collusion by allowing the bidders to signal their willingness to abstain from competing over certain objects, provided they are not challenged on others. In this way, the bidders can allocate the objects among themselves without paying much.[9]

As noted above, the problem of signaling is one more example of how the "Linkage Principle" is falsified.

B. The Cramton-Schwartz Empirical Studies of the PCS D, E, and F Block Auction.

In 1999, Peter Cramton and Jesse A. Schwartz circulated the results of an extensive study of code bidding and retaliatory bidding, two primary methods of signaling, in the Personal Communications Services (PCS) auction for broadband frequency blocks D, E, and F (auction 11), held from August 1996 to January 1997.[10] While Cramton and Schwartz found relatively small direct demand reduction effects in this auction—$29.8 million to $38.1 million, depending on the estimation method—they found that signaling bidders paid 36 percent less than non-signaling bidders for the D and E blocks and 18 percent less for the F block. As they concluded, "[g]iven that signaling bidders won about 40% of the available licenses, this indicates that the indirect losses associated with signaling may be quite large."[11]

In 2000, Cramton and Schwartz published more evidence of collusion arising from signaling in the PCS D, E, and F Block auction.[12] They found a pattern which confirmed the demand reduction effects of retaliatory bidding. AT&T was both the most successful bidder and a retaliatory bidder:

> One reason for avoiding a bidder is because the bidder has a reputation for blanket retaliation or other types of aggressive bidding. Another reason to avoid a bidder is that if the bidder has deep financial resources, then there is little reason to believe that a license can be won if that bidder is interested in it. Note that these reasons are not mutually exclusive. If a bidder thinks that the other bidder has a large enough budget to win any license it wants, and there is some probability that the bidder protects the licenses it wants with retaliation, then to bid against this bidder risks a substantial cost—namely, raising the prices on the other licenses the bidder wants. Suppose there is one large bidder that wants many licenses in the auction. If it is possible to keep the prices low on the licenses this bidder will win, then this bidder may be willing to demand reduce. It sacrifices some

> licenses it values in order to keep its overall prices low. Thus, bidders have the incentive to avoid the large bidder, letting the large bidder win the licenses it wants at low prices.
>
> Though our reasons why bidders avoid certain others are speculative, that this is a real phenomenon is not. In the DEF auction, AT&T won 223 licenses—more licenses than anyone else. These licenses covered 140 million people, over 50% more than any other bidder. To explore whether bidders avoided AT&T, we looked at all of the bids that occurred after round 10 on the D and E blocks in markets on which AT&T was the high bidder. We ask the question: Did bidders bump AT&T when AT&T was the high bidder on the less expensive of the two blocks? If bidders did not care about the identity of the high bidder, they would arbitrage the prices of the D and E blocks, and bid against AT&T if the other block was more expensive. This did not happen. When the other block was 15% more expensive (the bidding increments were 5% or 10% of the standing high bid in the DEF auction), bidders still bid on the other block 32% of the time rather than bid against AT&T on the less costly block. When the other block was 25% more expensive, bidders still avoided AT&T 31% of the time. Even when the price of the other block was 50% higher, bidders bid on the higher priced block 27% of the time.
>
> As a comparison, we performed this same exercise to see if bidders systematically avoided smaller bidders in the same way. We chose five bidders who won between 9 and 14 licenses—ACCPCS, Comcast, Rivgam, PAccess, and Touch. We counted all of the bids made by other bidders when one of these five bidders was the standing high bidder on the D or the E block. When the other blocks were 15%, 25%, and 50% more expensive, bidders avoided these five bidders 20%, 18%, and 15% of the time, respectively.[13]

Thus, AT&T was able to deter other bidders from challenging it at a statistically significant rate far greater than a representative sample of smaller bidders. The tacitly collusive allocation of licenses which resulted exhibited demand reduction.

II. Methodology

This study is in large part a replication of the Cramton and Schwartz 1999 empirical study of the PCS auction, applying the methodology which they developed to the AWS-1 auction (auction 66), held from August to September 2006. Cramton and Schwartz describe their methodology:

> To find the retaliating bids and code bids in the DEF auction, we needed a consistent way to comb through the 23,157 bids, looking for those bids resembling those examples in Section 3. Our strategy was to loop through each bid, to tentatively assume the bid was a retaliating bid, and then to check whether the bid met criteria characteristic of retaliating bids. For each bid, we used the reported information to determine which bidder made the bid, which bidder it bumped when it placed the bid (i.e., the standing high bidder as of the prior round), the market and block, and the round the bid was placed. For a bid to be a retaliating bid, it must be clear to the bidder being bumped that the bid was not meant to win the license, but was only meant to punish. Therefore, we first eliminated all bids made by a bidder that had shown interest by bidding on any block of the same market in the prior 10 rounds. Of course, if a retaliating bid was made in the previous 10 rounds, and then a follow-up retaliating bid was made, our algorithm did not catch the second retaliating bid—the program was designed to catch only the first retaliating bid.
>
> To be a retaliating bid, we required a clear motive: the bumped bidder must have recently been bidding for a market the retaliating bidder wanted. To ensure this, we required that

the bumped bidder bumped the retaliating bidder from some license in the prior two rounds. We also required that within two rounds of placing the retaliating bid, the retaliating bidder had bid on the contested market; otherwise, it is unclear what the retaliating bid was meant to accomplish.

If a bid met the above criteria, then it certainly met many characteristics of a retaliating bid. Our next step was to examine all of the bids returned from the above algorithm to further check that they resemble code bidding or retaliating bidding. Sometimes by looking at the retaliating bid we learned that the bid was not intended as retaliation. For example, if the bidder had bid on this market intermittently throughout the auction, then the bid was probably not meant to punish. Looking at the bids manually, we then eliminated any results returned by our algorithm included if:

1. The bidder did not consistently adhere to a punishment strategy. If it punished once and it was not successful in deterring its rival, and then no follow-up retaliating bids were placed, then we did not view this as a retaliating bid.

2. The retaliating bid worked too quickly. If only one retaliating bid was placed and on a market the retaliating bidder had shown interest on earlier in the auction, if the retaliating bid did not contain a relevant market number, and if the competitor conceded, then we view this as coincidental, and not strong enough evidence to conclude that this was a retaliating bid.

3. The intentions of the bidder were unclear. If the bidder and the punished bidder were competing contemporaneously on several markets, and the punishing bid did not contain a market number, then we view these bids as being ambiguous in intent.

4. The punished bidder did not securely hold the high bid on the license being punished. If a third bidder was bidding on this market in the three rounds prior to the punishing bid, then it is not clear that the punishment had any bite.[14]

Since changes to FCC auction rules since the PCS auction have made code bidding impossible, identification of code bidding was not necessary in this study. Furthermore, while Cramton and Schwartz excluded bids before the 40th round because few licenses were obtained that early and the exclusion made their analysis more tractable, it was not possible to do so in this case, because many important licenses were obtained before the 20th round. Bids in all rounds were, therefore, subjected to scrutiny. The AWS-1 auction involved 168 qualified bidders, who placed 16,197 bids on 1,087 licenses (the FCC held an additional 35 licenses on which no bids were placed by the end of the auction). The data used was provided by the FCC.

III. Retaliatory Bidding Occurred in the AWS-1 Auction

The algorithms described above identified 371 candidates for retaliatory bids from among 16,197 bids in the AWS-1 auction. Examination of these candidate bids based on the four subjective factors in the Cramton-Schwartz methodology identified 31 of these as retaliatory bids. These bids were then designated as successful if the signaling bidder placed the winning bid on the license it sought within five rounds of placing its retaliating bid(s); the absence of success is designated as unsuccessful. Table 1 presents this distribution:

Table 1.
Retaliatory Bids in the AWS-1 Auction

	BEA[15]	CMA[16]	Total
Successful	7	6	13
Unsuccessful	5	13	18
Total	12	19	31

Retaliatory bids constituted, 0.19 percent of all bids placed in the AWS-1 auction. In the PCS auction, Cramton and Schwartz identified 37 instances of retaliatory bidding, or 0.16 percent of all bids placed in the PCS auction. However, 23 of these bids constituted code bidding, which was not available to bidders in the AWS-1 auction, leaving 14 retaliatory bidding cases of the sort identified in the AWS-1 auction, or 0.06 percent of the PCS bids. It is clear that retaliatory bidding has increased in the AWS-1 auction over the rate found by Cramton and Schwartz in the PCS auction. The rate of successful retaliation has decreased slightly in the AWS-1 auction, 41.94% versus 51.35%. Retaliatory bids in the AWS-1 auction were significantly more likely to be successful for the Basic Economic Area (BEA) licenses than the Cellular Market Area (CMA) licenses; this is almost certainly an artifact of the higher rates of competition seen for the CMA licenses. No retaliatory bids on Regional Economic Area Group (REAG) licenses were observed. It should be noted that retaliatory bidding took place in an auction in which the general rate of competition – an average of three bidders per license – was regarded by the FCC as sufficiently high to eliminate it as a serious possibility.

IV. Demand Reduction Effects From Retaliatory Bidding Were Observed in the AWS-1 Auction

The indirect demand reduction effects of signaling arise from awareness on the part of bidders—and not just the bidder retaliated against—that other bidders are willing to engage in retaliatory bidding. This awareness creates risk aversion on the part of potentially threatened bidders who respond by avoiding challenging those bidders suspected of retaliatory bidding, lest they become victims of retaliation themselves. In these circumstances, it becomes irrelevant whether a retaliatory bidder's retaliations are successful a majority of the time, since there is no way to predict how effective a future retaliation will be. As a result, bidders who engage in retaliatory bidding are likely to acquire spectrum at lower prices than those who do not employ retaliatory bidding.[17] Demand reduction was indirectly measured by comparison of the mean price (measured as dollars/Mhz/population) paid for spectrum by bidders which used retaliatory bidding to that paid by bidders who did not. The mean price for spectrum paid by bidders who used retaliatory bidding was $0.092 per MHz/pop. The mean price for similar spectrum paid by bidders who did not use retaliatory bidding was $0.156 per MHz/pop.[18] A two-tailed t-test of the difference between the means was significant at $p = 0.0125$.[19] Retaliatory bidding significantly reduced prices for licenses for those bidders who engaged in it. This confirms the Cramton-Schwartz finding that indirect demand reduction effects are present when signaling occurs.

V. Conclusions

Careful examination of the evidence from the AWS-1 auction leads to a number of salient conclusions:

• Signaling remains a problem in FCC spectrum auctions; while code bidding was eliminated by a rule change, no effective measure against retaliatory bidding has been adopted.

• Signaling in the form of retaliatory bidding took place in the AWS-1 auction at a slightly higher rate than in the PCS D, E, and F Block auction. This was despite the claim that a modified eligibility ratio greater than three would eliminate it.

• Retaliatory bidding in the AWS-1 auction resulted in indirect demand reduction as evidenced by the significantly lower prices paid by retaliatory bidders for spectrum than by bidders who did not engage in retaliatory bidding.

• Signaling in the form of retaliatory bidding depends on the ability of retaliating bidders to identify target bidders and the licenses on which they are bidding. Anonymous bidding in the AWS-1 auction would have prevented this phenomenon entirely. As a side note, I offer that the results of the AWS-1 auction completely confirm my contentions in opposition to relaxing of the originally proposed anonymous bidding rules for the auction.[20]

Part Two: How Incumbents Blocked New Entrants in the AWS-1 Auction

I. Focus of the Study

Within days of the end of the AWS-1 auction, industry analysts and public interest activists were mourning the fate of the Wireless DBS coalition of satellite television providers that had been forced from the auction after failing to acquire any licenses in the face of opposition from a coalition of major incumbents. However, very little attention was paid to the specific dynamics of the interaction between incumbents and Wireless DBS in the auction, and no attempt was made to investigate whether a more general strategy of blocking new entrants who aspired to obtain a national AWS-1 footprint had been pursued. This study focuses on identifying the major incumbents, the new entrants who were targeted for blocking by those incumbents, and the strategies used by those incumbents against the targeted new entrants during bidding. This section evaluates the success of these blocking strategies and recommends remedies for preventing such blocking strategies in future spectrum auctions.

II. A Broader Definition of Market Structure is Necessary for Analysis of the AWS-1 Auction

It is necessary first to be clear about the market structure underlying the AWS-1 auction. The tendency to narrowly define this market as only encompassing wireless broadband obscures more than it illuminates, and it runs contrary to much current theorizing in industrial organization. The wireless broadband market is nested in a more general broadband market that extends to many firms that do not have substantial pre-existing wireless broadband deployments. Firms with substantial pre-existing DSL and cable modem broadband deployments must be regarded as critically-positioned incumbents for the AWS-1 auction. It is precisely the extraordinary capitalization resources of these latter firms, mainly cable and telephone companies, and their ability to integrate wireless broadband delivery with their existing systems, which had enormous

effect on their ability to succeed in the AWS-1 auction. This study, therefore, treats such bidders as incumbents.

III. The Absence of Anonymous Bidding in the AWS-1 Auction Facilitated Identification of New Entrants and the Incumbents' Blocking Strategy

The absence of anonymous bidding in the AWS-1 auction afforded opportunities for incumbents to identify new entrants who represented a serious competitive threat and block them by concentrating collectively on rapidly outbidding them on licenses necessary for acquisition of a national AWS footprint. These tactics, for example, placed the principal DBS bidder, Wireless DBS, at a considerable disadvantage. Wireless DBS was unable to acquire a national footprint at auction, particularly in the Cellular Market Area (CMA) and Regional Economic Area Grouping (REAG) licenses, in large part because incumbent telephone and cable broadband providers were able to identify and block Wireless DBS bids. Other new entrants, such as Atlantic Wireless, Antares Holdings, Dolan Family Holdings, and NTELOS Inc., were also blocked. Atlantic Wireless obtained only 12.20 percent of the licenses upon which it bid; Antares Holdings and Dolan Family Holdings, like Wireless DBS, obtained no licenses. NTELOS Inc. obtained 38.89 percent of the licenses it sought, but it is, as shown below, a special case. Wireless DBS was sufficiently blocked that it effectively withdrew from the auction after the eleventh round. Dolan Family Holdings withdrew after the twentieth round. Antares Holdings withdrew after the thirtieth round. Atlantic Wireless was able to persevere through the ninety-seventh round.

Notable among incumbents participating in such blocking behavior were T-Mobile License, SpectrumCo, and Cingular AWS. Barat Wireless,[21] MetroPCS AWS, Denali Spectrum License, and Cricket Licensee (Reauction),[22] Inc. also engaged in this blocking behavior. These incumbents obtained significant percentages of the licenses on which they bid: T-Mobile obtained 41.52 percent of the licenses on which it bid, SpectrumCo obtained 60.89 percent, Cingular AWS obtained 22.07 percent, Barat Wireless obtained 25.76 percent, and Cricket Licensee (Reauction) obtained 37.64 percent. MetroPCS AWS and Denali Spectrum acquired significantly less of the licenses on which they bid—12.12 percent and 5.88 percent, respectively. These two incumbents faced significant challenges from other incumbents as a result of intersecting bidding strategies. Although a major incumbent, Verizon chose less frequently to engage in blocking new entrant acquisition of a national footprint; it still obtained 61.90 percent of the licenses on which it bid.

IV. Identifying Major Incumbents and Targeted New Entrants

For purposes of this study, a major incumbent was defined as a bidder owned by firm(s) with significant, pre-existing, national or near-national broadband deployment, whether wireless or landline. A targeted new entrant was defined as an entrant which bid on ten or more licenses and which was challenged by two or more incumbents at a rate at least two standard deviations higher than the mean rate at which each incumbent challenged all bidders. A challenged incumbent was defined as an incumbent which was challenged by two or more incumbents at a rate at least two standard deviations higher than the mean rate at which each incumbent challenged all bidders. Table 2 shows the rate of challenge on licenses by incumbents in standard deviations from the mean number of challenges to all bidders by each incumbent (Tables 2, 4-9, 11, and 12 may be found in the Appendix). Note that Wireless DBS was challenged by all eight incumbents at a rate higher than two standard deviations from the mean of each incumbent; Atlantic Wireless, Antares Holdings, and Dolan Family Holdings were each challenged by four incumbents at a rate higher than two standard deviations from the mean of each incumbent. NTELOS Inc. was challenged by two incumbents at a rate higher than two standard deviations from the mean of each incumbent. No other new entrants were challenged at this rate by this array of incumbents.[23]

As Table 3 indicates, a two-tailed t-test revealed that the difference between the rate at which incumbents challenged targeted new entrants and the rate at which they challenged all other bidders was statistically significant for all incumbents except Barat Wireless:

Table 3.
Results of Two-Tailed t-Test of Difference Between the Mean Rates of Challenge by Incumbents Against Targeted New Entrants and Against All Other Bidders

	DF	T	P-value
T-Mobile License LLC	165	-4.3272	<0.0001
SpectrumCo LLC	165	-6.7935	<0.0001
Cingular AWS LLC	165	-8.6563	<0.0001
Cellco Partnership d/b/a Verizon Wireless	165	-4.1331	<0.0001
Denali Spectrum License LLC	165	-9.6572	<0.0001
MetroPCS AWS LLC	165	-7.8983	<0.0001
Cricket Licensee (Reauction), Inc.	165	-3.9016	0.0001
Barat Wireless LP	165	-1.4137	0.1593

No similar pattern of concentrated challenges by targeted new entrants was observed in the AWS-1. Table 4 shows the rate of challenge on licenses by targeted new entrants in standard deviations from the mean number of challenges to all bidders by each targeted new entrant. One targeted new entrant, Dolan Family Holdings, was challenged by two other targeted new entrants—Antares Holdings and Wireless DBS—at a rate higher than two standard deviations from the mean of those new entrants. Atlantic Wireless also came into conflict with two other targeted new entrants – Antares Holdings and NTELOS Inc. Only one incumbent, Denali Spectrum License, was challenged by two targeted new entrants—Antares Holdings and Wireless DBS—at a rate higher than two standard deviations from the mean of those new entrants. None of these cases were statistically significant. The lack of parity to the incumbents in concentrated challenges by targeted new entrants militates against the incumbent challenges being solely the consequences of similar underlying bidding strategy of the bidders involved.

V. Examination of the Bidding Profiles of Targeted New Entrants Discloses the Exclusionary Bidding Strategy of Major Incumbents

It may certainly be argued that the challenges of the incumbents to the targeted new entrants are simply an epiphenomenon of the fact that the spectrum at issue was highly sought by all bidders. This is not, in fact, true, since the bidding on the relevant spectrum primarily involved only incumbents and targeted new entrants. Furthermore, this argument seems to miss the point: most highly-prized licenses in the AWS-1 auction were highly-prized precisely because they offered complementarities to any bidder seeking a national footprint or seeking to block others from attaining that footprint. In order to determine exactly what underlies the pattern of concentrated challenges by incumbents, it is necessary to examine the bidding profiles of the targeted new entrants in some detail.

A. Antares Holdings LLC

Table 5 presents the bidding profile of Antares Holdings LLC. Antares Holdings aimed at creating a base in the eastern half of the U.S. and Texas with a combination of six BEA B Block and 15 C Block licenses, six CMA A Block licenses, and one REAG D Block license, covering 19 states, the District of Columbia, Puerto Rico, and the U.S. Virgin Islands with a coverage population of 130,058,101.[24] Antares Holdings is owned by a major investor in Northcoast Communications LLC, which held a PCS footprint roughly covering the same area as the licenses sought in the AWS-1 auction. Fifty of these PCS licenses were sold to Verizon for $750 million in 2003. Acquistion of the AWS licenses sought by Antares would have recreated a strong regional base in an area where Northcoast had dominated as a PCS provider and from which it could acquire a national AWS footprint in future auctions.

Five incumbents challenged Antares for the BEA B Block licenses, seven for the C Block licences, and four for the CMA A Block licenses. One incumbent challenged Antares for the REAG "D" Block license. SpectrumCo acquired the six BEA B Block Licenses. Cingular AWS acquired six of the BEA C Block licenses, SpectrumCo acquired three, Crick Licensee (Reauction) Inc. acquired two, T-Mobile License acquired one, and non-incumbents Vermont Telephone Company Inc., American Cellular Corporation, and Daredevil Communications acquired one each. Cingular AWS acquired the REAG D Block license. A number of incumbents did not persevere on these licenses beyond the withdrawal of Antares Holdings and other non-incumbents which were not seeking the same footprint went largely unchallenged. The appearance of a concerted effort by incumbents to block Antares Holdings is difficult to deny.

B. Atlantic Wireless LP

Table 6 provides the bidding profile of Atlantic Wireless LP. Atlantic Wireless sought 34 BEA B Block licenses, 48 C Block licenses, 39 CMA A Block licenses, one REAG E Block license and one REAG F Block license, covering 43 states, the District of Columbia, and the northeast region with a covered population of 375,251,473. Atlantic Wireless is primarily owned by Charles C. Townsend, founder of Aloha Partners LP, which dominated two earlier lower 700 MHz band auctions (77 licenses in auction 44 and 89 licenses in auction 49), owning 12 MHz of spectrum covering 60 percent of the United States—including all of the top 10 markets—and 84 percent of the population in the top 40 markets. Atlantic Wireless was a major contender for establishing a national AWS footprint.

Seven incumbents challenged for the BEA B and C Block licenses, eight for the CMA A Block licenses, one for the REAG E Block license, and seven for the REAG F Block license. Atlantic Wireless obtained two BEA B Block licenses. SpectrumCo obtained 24 BEA B Block licenses; Barat Wireless, Cellco Partnership d/b/a Verizon Wireless, Cingular AWS, Cricket Licensee (Reauction) Inc., and non-incumbents American Cellular Corporation and Cavalier Wireless obtained one each. Atlantic Wireless secured 12 BEA C Block licenses. Cingular AWS obtained 13 BEA C Block licenses, Cricket Licensee (Reauction) Inc. obtained nine, T-Mobile License obtained five, SpectrumCo obtained three, MetroPCS AWS obtained two, and non-incumbents Cavalier Wireless, Cincinnati Bell Wireless, Daredevil Communications, and Lynch AWS Corporation obtained one each. Atlantic Wireless won one CMA A Block license. T-Mobile License secured 17 CMA A Block Licenses, Cricket Licensee (Reauction) Inc. secured eight, Cingular AWS secured five, Barat Wireless secured one, and non-incumbents AWS Wireless Inc. secured six and Cincinnati Bell Wireless secured one. T-Mobile License and Cellco Partnership d/b/a Verizon Wireless obtained the REAG E and F Block licenses, respectively.

The swarm of incumbents to challenge Atlantic Wireless for all but the REAG E Block license, the failure of many incumbents to persevere when Atlantic Wireless ceased bidding on a license, and the acquisition of portions of this spectrum by non-incumbents who did not present a threatening profile strongly indicate that incumbents attempted to block acquisition of a national AWS footprint by Atlantic Wireless. Atlantic Wireless did manage to salvage a more restricted position in the face of this onslaught than did Wireless DBS, despite Wireless DBS's better capitalization; this is likely a consequence of Atlantic Wireless's more aggressive bidding strategy and willingness to engage in retaliatory bidding.

C. Dolan Family Holdings LLC

Table 7 provides the bidding profile for Dolan Family Holdings LLC. Dolan Family Holdings aimed at creating a regional base in the northeast with a combination of eight CMA A Block licenses and one each of the BEA B and C Block and the REAG D, E, and F Block licenses, covering six states and the northeast region with a coverage population of 221,258,219. The licenses sought by Dolan Family Holdings represented a strategy of acquiring dominance in the most potentially lucrative region to create a base from which to seek a future national footprint, since the principal stakeholders in Dolan Family Holdings also control Cablevision, the dominant cable provider in New York City. At every turn, it was faced by a swarm of concentrated challenges by incumbents: a total of four incumbents for the one BEA B Block license, five for the one BEA C Block license, six for the CMA A Block licenses, five for the REAG D and E Block licenses, and two for the REAG F Block license. SpectrumCo took the BEA B Block license, MetroPCS AWS took the BEA C Block license. T-Mobile License took four of the CMA A Block licenses and Cingular AWS took one, while non-incumbents American Cellular Corporation took two and AWS Wireless Inc. took one, respectively. MetroPCS AWS took the REAG D Block license, T-Mobile License took the E Block, and Verizon Wireless took the F Block. The majority of incumbents did not persevere on these licenses beyond the withdrawal of Dolan Family Holdings and other non-incumbents which were not seeking the same footprint went largely unchallenged. It is difficult to see how these patterns are explainable as anything but a successful, systematic attempt to block Dolan Family Holdings.

D. NTELOS Inc.

Table 8 provides the bidding profile of NTELOS Inc. NTELOS. is a classic example of a bidder with the bad luck to be in the wrong place at the wrong time. NTELOS aimed at constructing a Virginia-based network with overlap into neighboring states: three BEA C Block licenses and 15 CMA A Block licenses, covering Virginia and parts of four other states with a coverage population of 9,184,528. NTELOS Inc. was challenged by three incumbents for two of the BEA C Block licenses and by three incumbents for four of the CMA C Block licenses. Cingular AWS and Cricket Licensee (Reauction) Inc. each obtained one BEA C Block license, as did non-incumbent AWS Wireless Inc. Cingular AWS obtained two CMA A Block licenses and Cricket Licensee (Reauction) Inc. obtained one, while non-incumbents American Cellular Corporation and AWS Wireless Inc. took four and one, respectively. NTELOS successfully obtained seven CMA A Block licenses. The challenging incumbents persevered to victory and NTELOS was faced by several better capitalized non-incumbents. It was simply NTELOS's misfortune that its bidding profile intersected those of several incumbents. There is no evidence of a systematic blocking pattern in this case.

E. Wireless DBS LLC

Table 9 provides the bidding profile of Wireless DBS LLC. Wireless DBS presented the most complete attempt of any new entrant to establish a national AWS footprint, bidding on a BEA B Block license, a BEA C Block license, five CMA A Block licenses, and eight licenses in each of the REAG D, E, and F Blocks, covering ten states and eight regions with a coverage population of 974,451,444. An alliance of the two principal providers of DBS television, Wireless DBS sought to gain the terrestrial assets necessary for a national AWS system.

This attempt met with the strongest and most concentrated blocking attempt by the incumbents, as a round-by-round case study describes below. SpectrumCo obtained the BEA B Block license and MetroPCS AWS obtained the C Block license. T-Mobile License obtained three CMA A Block licenses and Cricket Licensee (Reauction) Inc. obtained two. T-Mobile License and MetroPCS AWS obtained two REAG D Block licenses each; Cingular AWS, Denali Spectrum Holdings, SpectrumCo, and non-incumbent Spotlight Media Corp. each obtained one. T-Mobile License won four REAG E Block licenses; Barat Wireless, Cingular AWS, Cricket Licensee (Reauction) Inc., and non-incumbent American Cellular Corporation obtained one each. Cellco Partnership d/b/a Verizon Wireless acquired four REAG F Block licenses, T-Mobile License acquired three, and non-incumbent MTA Communications Inc. acquired one. The pattern of incumbent challenges, failure of many incumbents to persevere after Wireless DBS ceased bidding, and the success of less well-capitalized non-incumbents who did not possess Wireless DBS's threatening national footprint profile all militate for this case being a successful blocking action against a targeted new entrant. Wireless DBS was routed by concerted incumbent action.

VI. Effects of the Major Incumbents' Exclusionary Strategy

The effects of this exclusionary strategy were striking, as Table 10 discloses:

Table 10.
Comparison of Incumbents to Targeted Non-Incumbent in the AWS-1 Auction

Incumbents	**Total No. of Licenses Bid On**	**% of Licenses Bid On PWB**	**Round of Last Bid**	**Upfront Payment (in $million)**
Barat Wireless LP	66	25.76%	128	80.00
Cellco Partnership d/b/a Verizon Wireless	21	61.90%	135	383.34
Cingular AWS LLC	209	22.97%	114	500.00
Cricket Licensee (Reauction), Inc.	263	37.64%	115	255.00
Denali Spectrum License LLC	17	5.88%	109	50.00
MetroPCS AWS LLC	66	12.12%	108	200.00
SpectrumCo LLC	225	60.89%	121	637.71
T-Mobile License LLC	289	41.52%	149	583.52
Mean	144.50	33.59%	122.38	336.20
Targeted Non-Incumbents				

Antares Holdings LLC	28	0.00%	30	21.00
Atlantic Wireless LP	123	12.20%	97	52.00
Dolan Family Holdings LLC	13	0.00%	20	149.98
NTELOS Inc.	18	38.89%	104	2.66
Wireless DBS LLC	32	0.00%	11	972.55
Mean	42.8	10.22%	52.4	239.64

Incumbents who targeted new entrants did more than three times better on average at acquiring sought-after licenses than the targeted new entrants and they were able to persist in the auction on average more than twice as long than the targeted new entrants. Three of the new entrants—Antares Holdings, Dolan Family Holdings, and Wireless DBS—were excluded entirely from acquiring spectrum.

The case of Wireless DBS is particularly telling because it implies that initial capitalization of any particular new entrant can be defeated by a "piling on" effect. Even an initial capitalization of $972,550,000 can be swamped when firms whose combined initial capitalization totals $2,256,230,000 systematically challenge every bid. It is hardly surprising that Wireless DBS withdrew after the eleventh round.

Even more interesting is the fact that the major incumbents were apparently willing to pay a significant premium for engaging in the blocking bidding strategy: on average, they paid 2.5 times more for the spectrum which they acquired than bidders who did not engage in this strategy. The difference in means between the dollars/MHz/pop price paid by major incumbents and all other bidders was statistically significant ($t = 4.812$, $p < 0.0001$).

This strategy adopted by major incumbents in the AWS-1 auction confirms Simon Wilkie's contention:

> [S]tandard FCC spectrum auctions, such as the recent AWS auction, strongly favor local geographic incumbent bidders and disfavor bidders with a national footprint business plan and actively discourage out-of-region competition. This likely means that new entrants, who will need such strategies in order to effectively compete with incumbent wireless providers, are disadvantaged by the auction design.[25]

VII. Exactly How the Major Incumbents Excluded Wireless DBS: A Case Study

Table 11 shows the strategic plan of Wireless DBS for acquiring a national AWS footprint and exactly how it was blocked by major incumbents. Wireless DBS's strategy to obtain national AWS footprint initially concentrated on the REAG licenses, particularly the F block. However, almost immediately, a threateningly consistent pattern of challenges from the major incumbents emerged from the first round: in two F blocks (AW-REA003-F – Great Lakes and AW-REA006-F – West) it received six challenges in the first round, in another (AW-REA004-F – Mississippi Valley) it received five, in three others (AW-REA001-F – Northeast, AW-REA002-F – Southeast, and AW-REA005-F – Central) it received four, and in another (AW-REA008-F – Hawaii) it received three.[26] On four of these F block licenses, additional pile-on challenges by other major incumbents took place in later rounds. These developments led to a decision to

suspend bidding on two F block licenses in the ninth round (AW-REA001-F – Northeast and AW-REA006-F – West) and one F block license in the tenth round (AW-REA002-F – Southeast).

The strong challenges to acquisition of REAG F block licenses also occasioned two fundamental readjustments of Wireless DBS's strategy—trying to accumulate necessary backup spectrum in the CMA blocks in the northeast, southeast, central, and western regions, and BEA C and D block licenses in the northeast, in the event that its REAG strategy were to fail. While Wireless DBS bid on AW-CMA001-A (New York-Newark) from the first round, in the fourth round it bid on AW-CMA003-A (Chicago), AW-CMA004-A (Philadelphia), and AW-CMA008-A (Washington, DC-MD-VA), and was met by strong challenge from T-Mobile License in each. In round ten, Wireless DBS attempted to break out of the stranglehold to its acquisition of an F block license in the west by bidding on AW-CMA007-A (San Francisco-Oakland); again it was met by T-Mobile. The attempts on AW-BEA010-B (NYC-Long Is. NY-NJ-CT-PA-MA-VT) in the fifth round and AW-BEA010-C (NYC-Long Is. NY-NJ-CT-PA-MA-VT) in the seventh round were equally abortive, resulting in withdrawal after the tenth round from both in the face of opposition from Cingular AWS, MetroPCS AWS, , SpectrumCo, and Cingular AWS alone, respectively.

In the REAG D and E blocks different, but equally threatening patterns quickly emerged:

- Confrontation by one or more major incumbents in the first round, followed by pile-on of several additional major incumbents from the fourth to eleventh rounds (AW-REA001-D, AW-REA003-D, AW-REA004-D, AW-REA005-D, AW-REA006-D, AW-REA001-E, AW-REA002-E, AW-REA003-E, AW-REA004-E, AW-REA005-E, and AW-REA006-E, and AW-REA008-E). At no point in bidding on these licenses did Wireless DBS face less than three incumbents, except Hawaii, where it faced two.

- On AW-REA001-D (Northeast) and AW-REA002-D (Southeast) Wireless DBS faced the REAG F block pattern: multiple initial challenges from major incumbents.

By the seventh to tenth rounds it was apparent that Wireless DBS was effectively blocked from acquiring the REAG D and E block licenses necessary for a national footprint. By the eleventh round this was equally apparent for the REAG F block licenses. Wireless DBS perforce withdrew from the auction after the eleventh round.

There are a set of tantalizing patterns of incumbent behavior in the REAG D and E blocks which suggests that more than tacit collusion may have been involved. SpectrumCo bid entered in the first round against Wireless DBS 56.33 percent of the time when it entered. T-Mobile License entered in the first round 75.00 percent of the time when it entered. MetroPCS AWS entered in the sixth or ninth rounds 66.67 percent of the time when it entered. Barat Wireless LP entered in the eighth round 75.00 percent of the time when it entered. Cingular AWS entered in the ninth or tenth round 75.00 percent of the time when it entered. These patterns are not maintained in the bidding of these incumbents on licenses on which Wireless DBS did not bid and it is difficult to see a strategic reason for this pattern to hold in the REAG D, E, and F blocks on which Wireless DBS bid except as a blocking hierarchy: SpectrumCo and T-Mobile were the early round blockers, MetroPCS AWS and Barat Wireless were the mid-to-late round reinforcements, and Cingular AWS was the late round reinforcement. It is difficult to see how this pattern emerged by chance.

The incumbents were remarkably blithe about which incumbent ultimately acquired the licenses. Verizon, which was the least significant blocker of targeted new entrants, did quite well. The ultimate allocation generally continued the pattern of incumbents securing spectrum in

geographic regions in which they were already hegemonic and avoiding competition within those regional hegemonies. Furthermore, a strong pattern emerged in which the majority of incumbents ceased to pursue the licenses they were challenging once it became apparent that Wireless DBS had dropped out. Table 12 displays these findings for the vital REAG F Block. Only Verizon and T-Mobile routinely persevered to the end for the REAG F Block. The remainder routinely ceased bidding on these crucial licenses immediately after Wireless DBS had withdrawn. This suggests that the bidding prior to Wireless DBS' withdrawal was less "competition" for these licenses than strategic blocking to prevent Wireless DBS from acquiring them.

VIII. Conclusions

Careful examination of the evidence from the AWS-1 auction leads to a number of salient conclusions:

- There was a concerted effort by major incumbents to target those new entrants which harbingered significant potential competitive broadband threat if (1) they acquired a national AWS footprint in the AWS-1 auction or (2) they acquired a strong regional or multi-regional base from which they could acquire national footprint in future auctions.

- Such targeted new entrants were met with a strategy of blocking bidding (i.e., coalitions of multiple major incumbents which bid for the purpose of denying licenses to the new entrant rather than acquiring the licenses for themselves). A majority of the major incumbents ceased bidding on such licenses after the targeted new entrant ceased bidding.

- The strategy of blocking bidding was extremely successful. Of the four targeted new entrants against whom blocking bidding was deployed, only one managed to obtain any spectrum in the auction. A less competitive market resulted from the AWS-1 auction.

- Major incumbents found the strategy of blocking bidding to deny targeted new entrants sufficiently useful to be willing to pay a significant premium for it: they paid on average 2.5 times more for the spectrum they obtained than bidders who did not use this strategy.

- Blocking bidding was possible only because incumbents were able to identify the licenses which targeted new entrants sought in the auction. If anonymous bidding had been used, this strategy would not have been available.

Part Three: Recommendations

Anonymous bidding remains the only strategy for effectively defeating retaliatory bidding, blocking bidding and other forms of tacit collusion.[27] Peter Cramton has argued for anonymous bidding:

> Concealing bidder identities. This prevents the use of targeted punishments against rivals. Unless there are strong efficiency reasons for revealing identities, anonymous auctions may be preferable.[28]

Other economists have pointed out the anti-collusive benefits of anonymous bidding. Paul Klemperer makes some useful points in a discussion of sealed-bid auctions:

> The general conclusion is that ascending auctions are more susceptible to collusion, and this is particularly the case when, as in our example, many auctions of different car models and different consumers are taking place simultaneously. As has been observed in the US and German auctions of radio spectrum, for example, bidders may be able to tacitly coordinate on dividing up the spoils in a simultaneous ascending auction. Bidders can use the early rounds when prices are still low to signal their views about who should win which objects, and then, when consensus has been reached, tacitly agree to stop pushing prices up. The same coordination cannot readily be achieved in simultaneous sealed-bid auctions, where there is neither the opportunity to signal, nor the ability to retaliate against a bidder who fails to cooperate. The conclusion is less stark when there are many repetitions over time, but it probably remains true that coordination is easier in ascending auctions. Furthermore, as is already well understood in the industrial-organization literature, this conclusion is strengthened by the different observabilities of internet and dealer sale prices which make mutual understanding of firms' strategies, including defections from "agreements," far greater in the internet case… Furthermore, this analysis ignores the impact of auction type on new entry
>
> in the presence of asymmetries. Because an "ascending" auction is generally efficient, a potential competitor with even a slightly higher cost (or lower quality) than an incumbent will see no point in entering the auction. However, the same competitor might enter a sealed-bid auction which gives a weaker bidder a shot at winning. The extra competition may lower prices very substantially. Of course the entry of the weaker competitor may also slightly reduce efficiency, but if competition is desirable per se, or if competition itself improves efficiency, or if the objective is consumer welfare rather than efficiency, then the case for sealed-bid auctions is very strong…[29]

Sealed bidding in standard first-price auctions performs the same functions as anonymous bidding in ascending auctions: it limits opportunities for collusion and reduces the likelihood that the presence of large bidders will deter smaller bidders from entry.

The principal arguments for retaining open bidding are (1) transparency, (2) the "Linkage Principle," and (3) a variant of the "Linkage Principle" which suggests that higher revenues can be obtained in situations where a bidder's valuation is dependent on the identity of bidders for geographically adjacent licenses. There seems little reason to be concerned with transparency prior to and during an auction: the need for transparency to verify bids and ensure rule compliance can be met by release of bidder identities and bids at the end of the auction. The "Linkage Principle" has been savaged in the theoretical literature and substantial empirical evidence is now available to falsify it: the demand reduction effects of signaling and other collusive behaviors make it difficult to believe that revelation of bidder identities maximizes auction revenue. Even if one concedes that slightly higher revenues may result from open bidding where a bidder's valuation is dependent on the identity of bidders for geographically adjacent licenses, there is no resason to believe that it necessarily offsets the demand reduction effects of signaling and it certainly does not address the entry deterrence effects of retaliatory bidding or bidder size. The question is: what strong efficiency reasons exist for open bidding? The answer is none.

Strict anonymous bidding rules should be adopted for future FCC spectrum auctions, including the 700 MHz auction.

Appendix

Table 2.[30]
Rate of Challenge by Incumbents in Standard Deviations from the Mean of Each Incumbent

	Challenging Incumbents							
Challenged Bidders	**T-Mobile License LLC**	**SpectrumCo LLC**	**Cingular AWS LLC**	**Cricket Licensee (Reauction), Inc.**	**Barat Wireless L.P.**	**Cellco Partnership d/b/a Verizon Wireless**	**Denali Spectrum License LLC**	**MetroPCS AWS LLC**
18th Street Spectrum LLC	0.5769	0.1334	-0.1065	0.0313	1.4360	-0.2013	-0.1858	-0.2559
3 Rivers Telephone Cooperative Inc	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
ACS Wireless License Sub Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Advanced Communications Technology Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Agri-Valley Communications	0.2794	-0.4724	-0.0820	-0.5292	-0.3930	-0.2013	-0.1858	0.3565
Alenco Communications Inc.	0.2794	-0.4724	-0.4508	0.6719	-0.3930	-0.2013	-0.1858	-0.2559
Allcom Communications Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
American Cellular Corporation	0.4686	0.2937	0.3298	0.3751	0.5640	-0.2013	-0.0554	-0.1063
Antares Holdings LLC	1.7670	**2.7728**	**3.0532**	**2.0231**	0.0969	-0.2013	0.6156	**3.1122**
Arapahoe Telephone Company d/b/a ATC Communication	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
AST Telecom LLC	-0.4644	4.0708	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Atlantic Seawinds Communications LLC	4.7421	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Atlantic Wireless LP	**2.1600**	**2.6672**	**2.7818**	**2.0341**	1.6144	0.5377	0.2703	-0.2559
AWS Wireless Inc.	1.1594	0.8897	0.8999	0.9172	0.4074	0.1035	0.0173	0.4859
Aztech Communications Inc.	-0.4644	-0.4724	-0.4508	**3.6746**	-0.3930	-0.2013	-0.1858	-0.2559
Barat Wireless LP	1.5078	1.5927	**2.1311**	-0.5292	-	0.7169	0.4941	0.3936
Beehive Telephone Company Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
BEK Communications Cooperative	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Bend Cable Communications LLC	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Big Bend Telecom LTD	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Big River Telephone Company LLC	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Blackfoot Telephone Cooperative Inc	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Blue Valley Tele-Communications Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Bluestreak Wireless LLC	0.1141	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
BPS Telephone Company	4.7421	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Breda Telephone Corp.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
C&W Enterprises Inc.	-0.4644	-0.4724	-0.4508	-0.3136	-0.3930	-0.2013	-0.1858	-0.2559
Cable One Inc	-0.4644	-0.4724	-0.4508	-0.5292	-0.0413	-0.2013	-0.1858	-0.2559
Cal-Ore Telephone Co.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Carolina Personal Communications Inc.	4.7421	0.6634	0.8402	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Carolina West Wireless Inc	0.8372	-0.1928	0.6084	0.1014	0.9787	-0.2013	-0.1858	0.3157
Cavalier Wireless LLC	0.7905	1.4747	-0.4508	0.5918	-0.0413	1.0418	-0.1858	-0.2559
CCTN Biddng Consortium	-0.4644	1.9074	1.7623	-0.5292	-0.3930	-0.2013	1.4170	0.5606
Cellco Partnership d/b/a Verizon Wireless	1.0232	1.9074	0.5174	1.0723	0.9134	-	-0.1858	-0.2559
Cellular South Licenses Inc.	0.8792	0.3795	1.0680	1.7041	0.0357	-0.2013	-0.1858	0.2484

Centennial Michiana License Company LLC	0.7607	0.0621	-0.4508	-0.2819	-0.3930	-0.2013	-0.1858	1.3516
Central Texas Telephone Investments LP	-0.4644	-0.4724	-0.4508	-0.2664	-0.3930	-0.2013	-0.1858	-0.2559
Central Utah Telephone Company	-0.4644	-0.4724	0.0583	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
CenturyTel Broadband Wireless LLC	0.2689	0.5515	**3.2376**	0.6550	0.9594	1.9324	-0.1858	-0.2559
Chariton Valley Communication Corporation Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Chequamegon Communications Cooperative Inc	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Chester Telephone Company	-0.4644	-0.4724	-0.4508	3.6746	-0.3930	-0.2013	-0.1858	-0.2559
Churchill County Telephone d/b/a CC Communications	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Cincinnati Bell Wireless LLC	0.5369	1.4498	0.5422	0.7643	-0.3930	-0.2013	-0.1858	1.8362
Cingular AWS LLC	1.8524	**2.3318**	-	1.8845	1.7729	1.1035	0.6731	-0.2559
City of Ketchikan dba Ketchikan Public Utilities	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Clay County Rural Telephone Cooperative Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Clinker LLC	-0.4644	-0.4724	-0.4508	**3.6746**	-0.3930	-0.2013	-0.1858	-0.2559
Coleman County Telecommunications LTD	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Command Connect LLC	-0.4644	1.1178	-0.4508	0.9422	-0.3930	**8.8884**	-0.1858	0.1728
Comporium Wireless LLC	2.1389	-0.4724	-0.4508	1.5727	-0.3930	-0.2013	-0.1858	-0.2559
Craw-Kan Telephone Cooperative Inc	-0.4644	-0.4724	1.9053	0.3116	-0.3930	-0.2013	-0.1858	-0.2559
Cricket Licensee (Reauction) Inc	1.4955	1.6524	-0.4508	-	1.4325	0.7204	0.4114	0.9502
Cross Telephone Company	-0.4644	-0.4724	-0.4508	0.3116	**2.3505**	-0.2013	-0.1858	-0.2559
CTC Telcom Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Dakota Wireless Group LLC	-0.4644	-0.4724	0.3571	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Daredevil Commuinications LLC	0.4565	0.9184	**4.4093**	0.5575	0.1669	0.0048	-0.1095	0.3857
Denali Spectrum License LLC	1.0669	**3.5363**	-0.4508	**2.9328**	**2.8346**	**5.1456**	-	**5.2915**
Diller Telephone Company	-0.4644	-0.4724	-0.4508	-0.5292	**6.4657**	-0.2013	-0.1858	-0.2559
Dolan Family Holdings LLC	1.9386	1.6245	**3.1242**	1.0877	-0.3930	**2.1294**	**4.1295**	**3.7010**
Ellijay Telephone Company	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
ETCOM LLC	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Farmers Mutual Telephone Company	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Farmers Telecommunications Cooperative Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Fidelity Communications Company	-0.4644	-0.4724	-0.4508	-0.1470	-0.3930	-0.2013	-0.1858	-0.2559
FMTC Wireless Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
FTC Management Group Inc.	-0.4644	1.7992	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Graceba Total Communications Inc	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Grand River Communications Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Granite State Long Distance Inc.	**2.1389**	-0.4724	**2.1311**	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Green Hills Area Cellular Telephone Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Hancock Rural Telephone Corporation	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Hawaiian Telcom Communications Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Heart of Iowa Communications Cooperative	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Hemingford Cooperative Telephone Company	-0.4644	-0.4724	-0.4508	1.5727	0.5215	-0.2013	-0.1858	-0.2559
Hill Country Telephone Cooperative Inc	-0.4644	1.7992	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559

Horry Telephone Cooperative Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Innovative Communication Corporation	-0.4644	4.0708	-0.4508	-0.1088	-0.3930	-0.2013	-0.1858	-0.2559
Iowa Intelegra Consortium LLC	0.5769	-0.4724	0.5820	-0.5292	**3.0364**	-0.2013	-0.1858	-0.2559
Iowa Telecommunications Services Inc	-0.2474	0.6634	-0.0205	-0.5292	1.3217	-0.2013	-0.1858	-0.2559
James Valley	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Jefferson Telephone Company	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Kingdom Telephone Company	-0.4644	-0.4724	-0.4508	0.8721	-0.3930	-0.2013	-0.1858	-0.2559
KTC AWS Limited Partnership	-0.4644	-0.4724	-0.0536	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
La Ward Cellular Telephone Company Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
LCDW Wireless Limited Partnership	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Leaco Rural Telephone Cooperative Inc	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Ligtel Communications Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
LL License Holdings II LLC	0.0395	0.1139	0.8818	-0.2580	**2.7045**	-0.2013	-0.1858	-0.2559
Lynch AWS Corporation	1.4881	0.6634	0.1947	-0.0037	1.3217	-0.2013	-0.1858	0.8158
MAC Wireless LLC	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Manti Telephone Company	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
McDonald County Telephone Company	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Mediapolis Telephone Company	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
MetroPCS AWS LLC	**2.3755**	**3.1760**	**3.5394**	1.8275	0.6462	0.7169	1.6841	-
Midwest AWS Limited Partnership	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Mt. Vernon. Net Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
MTA Communications Inc.	0.2794	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	1.4170	-0.2559
MTPCS License Co. LLC	-0.4644	-0.1316	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Muenster Telephone Corp. of Texas	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Mutual Telephone Company	-0.4644	1.0420	-0.4508	-0.5292	**4.1795**	-0.2013	-0.1858	-0.2559
NEIT Wireless LLC	-0.4644	-0.4724	0.2869	-0.5292	**3.5263**	-0.2013	-0.1858	-0.2559
North Dakota Network Company	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Northeast Missouri Rural Telephone Company	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Northeast Nebraska Telephone Company	-0.4644	-0.4724	-0.4508	-0.5292	3.0364	-0.2013	-0.1858	-0.2559
Northern Iowa Communications Partners LLC	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Northwest Missouri Cellular Limited Partnership	2.1389	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
NSIGHTTEL Wireless LLC	0.5273	-0.4724	0.7787	-0.5292	1.5666	-0.2013	-0.1858	-0.2559
NTELOS Inc.	0.4034	**2.5564**	**2.9918**	0.8721	-0.3930	-0.2013	-0.1858	-0.2559
Palmetto Rural Telephone Cooperative Inc.	1.2711	1.0420	**2.9918**	**2.2734**	-0.3930	-0.2013	-0.1858	-0.2559
Panhandle Telecommunication Systems Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Panora Telecommunications Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Partnership Wireless LLC	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Paul Bunyan Rural Telephone Cooperative	-0.4644	-0.4724	0.1947	-0.0037	-0.3930	-0.2013	-0.1858	-0.2559
PCS Partners L.P.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Perry-Spencer Rural Telephone Coop. Inc. dba PSC	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
PetroCom License Corporation	-0.4644	-0.4724	-0.4508	1.5727	-0.3930	-0.2013	-0.1858	-0.2559
Pine Cellular Phones Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Plains Cooperative Telephone Association Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559

Plateau Telecommunications Inc.	0.1141	-0.2200	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	0.2204
Public Service Wireless Services Inc.	-0.1751	1.2944	-0.1639	0.1715	-0.3930	-0.2013	-0.1858	-0.2559
Rainbow Telecommunications Association Inc.	-0.4644	-0.4724	-0.4508	**3.6746**	-0.3930	-0.2013	-0.1858	-0.2559
Red Rock Spectrum Holdings LLC	-0.4644	-0.1633	-0.3103	-0.3290	0.0736	-0.2013	-0.1858	-0.1976
Reservation Telephone Cooperative Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Roberts County Telephone Cooperative Association	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Rodriguez Marcos	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Ropir Communications Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Route 66 Wireless LLC	-0.4644	-0.4724	-0.4508	0.0714	-0.3930	-0.2013	-0.1858	-0.2559
Salina Spavinaw Telephone Co.Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Sandhill Communications LLC	-0.4644	-0.4724	-0.4508	**3.6746**	-0.3930	-0.2013	-0.1858	-0.2559
Shenandoah Mobile Company	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Shoreline Investments LLC	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
SKT Inc.	-0.4644	-0.4724	0.5820	0.3116	**2.3505**	-0.2013	-0.1858	-0.2559
Smithville Spectrum LLC	-0.4644	-0.4724	-0.4508	0.8721	-0.3930	-0.2013	-0.1858	-0.2559
South #5 RSA Limited Partnership d/b/a Brazos Cell	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
South Slope Cooperative Telephone Company Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Southeastern Indiana Rural Telephone Coop. Inc.	-0.4644	-0.4724	-0.4508	1.5727	-0.3930	-0.2013	-0.1858	-0.2559
Space Data Spectrum Holdings LLC	0.0090	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	0.8341	-0.2559
SpectrumCo LLC	0.8219	-	**2.1615**	1.4985	1.2208	-0.2013	0.4741	1.5260
Spotlight Media Corp	0.2794	0.8257	0.5328	-0.1288	0.2602	-0.2013	-0.1858	-0.2559
St. Cloud Wireless Holdings LLC	**3.4405**	-0.4724	-0.4508	0.5218	-0.3930	-0.2013	-0.1858	-0.2559
Stayton Cooperative Telephone Company	-0.4644	-0.4724	-0.4508	0.5218	-0.3930	-0.2013	-0.1858	-0.2559
Telephone Electronics Coporation	-0.4644	-0.4724	0.1947	0.5218	-0.3930	-0.2013	-0.1858	-0.2559
The Chillicothe Telephone Company	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
The Pioneer Telephone Association Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
The S&T Telephone Cooperative Association Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
The Tri-County Telephone Association Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Three River Telco	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
T-Mobile License LLC	-	0.8324	1.5861	1.2309	1.2208	0.6375	0.3189	1.2274
Triad AWS Inc.	0.8372	1.6960	1.6617	1.0950	1.1658	0.4873	0.5791	1.3029
Tri-Valley Communications LLC	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Union Telephone Company	-0.4644	-0.2748	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
United Telephone Mutual Aid Corp.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
United Wireless Communications Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Van Buren Wireless Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Vermont Telephone Company Inc.	0.0090	0.5372	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Volcano Internet Provider	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
West Carolina Piedmont Bidding Consortium	-0.4644	-0.4724	-0.4508	**2.2734**	-0.3930	-0.2013	-0.1858	-0.2559
West Central Communications LLC	-0.4644	-0.4724	0.5820	0.3116	-0.3930	-0.2013	-0.1858	-0.2559
West Central Telephone Association	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559

Western New Mexico Telephone Company Inc.	-0.4644	1.7992	**2.1311**	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Wheat State Telephone Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
Wireless DBS LLC	**2.7897**	**3.6449**	**3.9062**	**2.2296**	**2.1790**	**6.4266**	**3.6710**	**4.8345**
Wittenberg Telephone Company	0.4823	-0.4724	1.0984	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
WUE INC	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
WWW Broadband LLC	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
XIT Leasing Inc.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559
XIT Telecommunication & Technology Ltd.	-0.4644	-0.4724	-0.4508	-0.5292	-0.3930	-0.2013	-0.1858	-0.2559

Two or more standard deviations from incumbent mean

Targeted New Entrant
Challenged Incumbent

Table 4.[31]

Rate of Challenge by Targeted New Entrants in Standard Deviations from the Mean of Each Targeted New Entrant

	Challenging New Entrants				
Challenged Bidders	**Antares Holdings LLC**	**Atlantic Wireless LP**	**Dolan Family Holdings LLC**	**NTELOS Inc.**	**Wireless DBS LLC**
18th Street Spectrum, LLC	-0.1598	0.5881	-0.1396	0.6149	-0.2210
3 Rivers Telephone Cooperative Inc	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
ACS Wireless License Sub, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Advanced Communications Technology, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Agri-Valley Communications	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Alenco Communications, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Allcom Communications, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
American Cellular Corporation	0.2746	0.5114	0.0019	0.2615	-0.0029
Antares Holdings LLC	**-**	**3.8223**	1.1643	-0.1263	0.1140
Arapahoe Telephone Company d/b/a ATC Communication	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
AST Telecom, LLC	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Atlantic Seawinds Communications, LLC	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Atlantic Wireless LP	1.3154	-	0.1572	0.1449	0.0840
AWS Wireless Inc.	0.3127	0.9278	0.0318	0.0527	0.0621
Aztech Communications, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Barat Wireless LP	0.0019	1.5396	-0.1396	-0.1263	0.6317
Beehive Telephone Company, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
BEK Communications Cooperative	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Bend Cable Communications, LLC	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Big Bend Telecom, LTD	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Big River Telephone Company, LLC	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Blackfoot Telephone Cooperative Inc	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Blue Valley Tele-Communications, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Bluestreak Wireless LLC	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210

BPS Telephone Company	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Breda Telephone Corp.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
C&W Enterprises Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Cable One Inc	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Cal-Ore Telephone Co.	-0.1598	6.5040	-0.1396	-0.1263	-0.2210
Carolina Personal Communications, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Carolina West Wireless Inc	-0.1598	-0.3220	-0.1396	0.4296	-0.2210
Cavalier Wireless LLC	-0.0503	0.5881	-0.1396	-0.1263	-0.0286
CCTN Biddng Consortium	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Cellco Partnership d/b/a Verizon Wireless	-0.1598	0.6531	0.4399	-0.1263	**2.9056**
Cellular South Licenses, Inc.	-0.1598	0.1046	-0.1396	-0.1263	-0.2210
Centennial Michiana License Company LLC	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Central Texas Telephone Investments, LP	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Central Utah Telephone Company	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
CenturyTel Broadband Wireless LLC	-0.1598	0.0625	-0.1396	-0.1263	-0.2210
Chariton Valley Communication Corporation, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Chequamegon Communications Cooperative Inc	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Chester Telephone Company	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Churchill County Telephone d/b/a CC Communications	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Cincinnati Bell Wireless LLC	-0.1598	1.7783	-0.1396	-0.1263	-0.2210
Cingular AWS LLC	0.8105	**2.1928**	0.3845	0.1929	0.9908
City of Ketchikan dba Ketchikan Public Utilities	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Clay County Rural Telephone Cooperative, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Clinker LLC	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Coleman County Telecommunications, LTD	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Command Connect LLC	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Comporium Wireless, LLC	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Craw-Kan Telephone Cooperative Inc	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Cricket Licensee (Reauction) Inc	0.5301	1.6245	0.0918	0.0428	0.5280
Cross Telephone Company	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
CTC Telcom, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Dakota Wireless Group LLC	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Daredevil Commuinications LLC	0.3484	0.5138	-0.1396	-0.0507	-0.2210
Denali Spectrum License LLC	*1.0959*	*1.6856*	***3.4399***	*-0.1263*	***5.8483***
Diller Telephone Company	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Dolan Family Holdings LLC	**2.3033**	1.2532	-	-0.1263	**4.1082**
Ellijay Telephone Company	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
ETCOM, LLC	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Farmers Mutual Telephone Company	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Farmers Telecommunications Cooperative, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Fidelity Communications Company	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
FMTC Wireless, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
FTC Management Group, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Graceba Total Communications Inc	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Grand River Communications, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210

Granite State Long Distance, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Green Hills Area Cellular Telephone, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Hancock Rural Telephone Corporation	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Hawaiian Telcom Communications, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Heart of Iowa Communications Cooperative	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Hemingford Cooperative Telephone Company	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Hill Country Telephone Cooperative Inc	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Horry Telephone Cooperative, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Innovative Communication Corporation	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Iowa Intelegra Consortium LLC	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Iowa Telecommunications Services Inc	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
James Valley	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Jefferson Telephone Company	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Kingdom Telephone Company	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
KTC AWS Limited Partnership	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
La Ward Cellular Telephone Company, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
LCDW Wireless Limited Partnership	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Leaco Rural Telephone Cooperative Inc	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Ligtel Communications, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
LL License Holdings II, LLC	-0.1598	-0.1019	-0.1396	-0.1263	-0.2210
Lynch AWS Corporation	-0.1598	1.3845	-0.1396	-0.1263	-0.2210
MAC Wireless, LLC	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Manti Telephone Company	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
McDonald County Telephone Company	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Mediapolis Telephone Company	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
MetroPCS AWS, LLC	1.6191	1.8499	0.9668	-0.1263	**2.4793**
Midwest AWS Limited Partnership	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Mt. Vernon. Net, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
MTA Communications, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	1.1190
MTPCS License Co., LLC	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Muenster Telephone Corp. of Texas	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Mutual Telephone Company	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
NEIT Wireless, LLC	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
North Dakota Network Company	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Northeast Missouri Rural Telephone Company	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Northeast Nebraska Telephone Company	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Northern Iowa Communications Partners, LLC	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Northwest Missouri Cellular Limited Partnership	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
NSIGHTTEL Wireless, LLC	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
NTELOS Inc.	-0.1598	**4.2286**	-0.1396	-	-0.2210
Palmetto Rural Telephone Cooperative, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Panhandle Telecommunication Systems, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Panora Telecommunications, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Partnership Wireless LLC	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Paul Bunyan Rural Telephone Cooperative	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
PCS Partners, LP	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210

Perry-Spencer Rural Telephone Coop., Inc. dba PSC	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
PetroCom License Corporation	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Pine Cellular Phones, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Plains Cooperative Telephone Association, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Plateau Telecommunications, Inc.	-0.1598	0.0572	-0.1396	-0.1263	-0.2210
Public Service Wireless Services, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Rainbow Telecommunications Association, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Red Rock Spectrum Holdings, LLC	-0.1598	-0.2756	-0.1396	-0.1263	-0.2210
Reservation Telephone Cooperative, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Roberts County Telephone Cooperative Association	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Rodriguez, Marcos	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Ropir Communications, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Route 66 Wireless, LLC	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Salina Spavinaw Telephone Co.Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Sandhill Communications, LLC	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Shenandoah Mobile Company	-0.1598	-0.3220	-0.1396	**6.5449**	-0.2210
Shoreline Investments LLC	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
SKT, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Smithville Spectrum, LLC	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
South #5 RSA Limited Partnership d/b/a Brazos Cell	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
South Slope Cooperative Telephone Company, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Southeastern Indiana Rural Telephone Coop., Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Space Data Spectrum Holdings, LLC	-0.1598	-0.3220	-0.1396	-0.1263	**2.3371**
SpectrumCo LLC	0.6773	1.9533	0.1467	-0.0391	0.8457
Spotlight Media Corp	0.3484	0.6531	-0.1396	0.4031	0.6723
St. Cloud Wireless Holdings, LLC	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Stayton Cooperative Telephone Company	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Telephone Electronics Coporation	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
The Chillicothe Telephone Company	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
The Pioneer Telephone Association, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
The S&T Telephone Cooperative Association, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
The Tri-County Telephone Association, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Three River Telco	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
T-Mobile License LLC	0.4311	1.1896	0.3657	-0.0109	0.6553
Triad AWS, Inc.	1.0531	**2.0050**	0.1370	-0.1263	0.4185
Tri-Valley Communications, LLC	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Union Telephone Company	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
United Telephone Mutual Aid Corp.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
United Wireless Communications Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Van Buren Wireless, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Vermont Telephone Company, Inc.	**2.2120**	0.4364	-0.1396	-0.1263	-0.2210
Volcano Internet Provider	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
West Carolina Piedmont Bidding Consortium	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
West Central Communications LLC	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210

West Central Telephone Association	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Western New Mexico Telephone Company, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Wheat State Telephone, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
Wireless DBS LLC	0.1737	0.5312	**2.1423**	-0.1263	-
Wittenberg Telephone Company	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
WUE INC	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
WWW Broadband, LLC	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
XIT Leasing, Inc.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210
XIT Telecommunication & Technology, Ltd.	-0.1598	-0.3220	-0.1396	-0.1263	-0.2210

Challenged Targeted New Entrant
Challenged Incumbent

Table 5.
Bidding Profile of Antares Holdings LLC

	BEA		**CMA**	**REAG**			
	B Block	**C Block**	**A Block**	**D Block**	**E Block**	**F Block**	**Total**
No. of Licenses Sought	6	15	6	1	0	0	28
States/Areas Covered	DC, DE, MA, MD, NH, NJ, NY, PA, RI, VA, VT, WV	CT, DC, DE, FL, IA, IL, IN, MA, MD, MN, MO, NH, NJ, NY, PA, RI, TX, VA, VT, WI, WV	CT, MA, NH, NJ, NY, RI	PR, USVI	-	-	-
Population of Coverage Area	27,347,178	90,548,766	8,244,935	3,917,222	0	0	130,058,101
Challenging Incumbents (No. of Licenses Challenged)	Cingular AWS LLC (3), Cricket License (Reauction) Inc. (4), MetroPCS AWS LLC (3), SpectrumCo LLC (6), T-Mobile License LLC (3)	Barat Wireless LP (1), Cingular AWS LLC (14), Cricket License (Reauction) Inc. (11), Denali Spectrum License LLC (2), MetroPCS AWS LLC (7), SpectrumCo LLC (13),T-Mobile License LLC (7)	Cricket License (Reauction) Inc. (2), MetroPCS AWS LLC (1), SpectrumCo LLC (1), T-Mobile License LLC (6)	Cingular AWS LLC (1)	-	-	-
States/Areas Covered by Challenged Licenses	DC, DE, MA, MD, NH, NJ, NY, PA, RI, VA, VT WV	CT, DC, DE, FL, IA, IL, IN, MA, MD, MN, MO, NH, NJ, NY, PA, RI, TX, VA, VT,	CT, MA, NH, NJ, NY, RI	PR, USVI	-	-	-

		WI, WV					
Population of Coverage Area of Challemnged Licenses	27,347,178	90,548,766	8,244,935	3,917,222	-	-	130,058,101

Table 6.
Bidding Profile of Atlantic Wireless LP

	BEA		**CMA**	**REAG**			
	B Block	**C Block**	**A Block**	**D Block**	**E Block**	**F Block**	**Total**
No. of Licenses Sought	34	48	39	0	1	1	123
States/Areas Covered	AZ, CA, CO, DE, FL, HI, ID, IL, IN, KS, KY, MA, MD, ME, MI, MO, NC, NE, NH, NM, NV, NY, OH, OR, PA, RI, SC, TX, UT, VA, VT, WA, WI, WV	AL, AR, AZ, CA, CO, DC, DE, FL, GA, HI, IA, ID, IL, IN, KS, KY, MA, MD, MI, MN, MO, MS, NC, NE, NH, NJ, NV, OH, OK, OR, PA, RI, SC, TN, TX, UT, VA, VT, WA, WI, WV	AR, CA, CO, CT, FL, GA, HI, IL, IN, KS, KY, MA, MD, MI, MN, MO, MS, NC, NH, NJ, NV, OH, OR, PA, RI, TN, TX, UT, VA, WA, WI	-	HI	Northeast	-
Population of Coverage Area	72,544,094	161,946,246	89,491,506	-	1,211,537	50,058,090	375,251,473
Challenging Incumbents (No. of Licenses Challenged)	Barat Wireless LP (6), Cellco Partnership d/b/a Verizon Wireless (1), Cingular AWS LLC (18), Cricket Licensee (Reauction) Inc. (20), MetroPCS AWS LLC (4), SpectrumCo LLC (32), T-Mobile License LLC (5)	Barat Wireless LP (6), Cingular AWS LLC (35), Cricket Licensee (Reauction) Inc. (24), Denali Spectrum Holdings LLC (2), MetroPCS AWS LLC (10), SpectrumCo LLC (48), T-Mobile License LLC (20)	Barat Wireless LP (6), Cellco Partnership d/b/a Verizon Wireless (1), Cingular AWS LLC (25), Cricket Licensee (Reauction) Inc. (29), Denali Spectrum Holdings LLC (2), MetroPCS AWS LLC (7), SpectrumCo LLC (9), T-	-	T-Mobile License LLC (1)	Cellco Partnership d/b/a Verizon Wireless (1), Cingular AWS LLC (1), Cricket Licensee (Reauction) Inc. (1), Denali Spectrum Holdings LLC (1), MetroPCS AWS LLC (1), SpectrumCo LLC (1), T-Mobile License LLC	-

			Mobile License LLC (39)			(1)	
States/Areas Covered by Challenged Licenses	AZ, CA, CO, DE, FL, HI, ID, IL, IN, KS, KY, MA, MD, ME, MI, MO, NC, NE, NH, NM, NV, NY, OH, OR, PA, RI, SC, TX, UT, VA, VT, WA, WI, WV	AL, AR, AZ, CA, CO, DC, DE, FL, GA, HI, IA, ID, IL, IN, KS, KY, MA, MD, MI, MN, MO, MS, NC, NE, NH, NJ, NV, OH, OK, OR, PA, RI, SC, TN, TX, UT, VA, VT, WA, WI, WV	AR, CA, CO, CT, FL, GA, HI, IL, IN, KS, KY, MA, MD, MI, MN, MO, MS, NC, NH, NJ, NV, OH, OR, PA, RI, TN, TX, UT, VA, WA, WI	-	HI	Northeast	-
Population of Coverage Area of Challemnged Licenses	72,544,094	161,946,246	89,491,506	-	1,211,537	50,058,090	375,251,473

Table 7.
Bidding Profile of Dolan Family Holdings LLC

	BEA		**CMA**	**REAG**			
	B Block	**C Block**	**A Block**	**D Block**	**E Block**	**F Block**	**Total**
No. of Licenses Sought	1	1	8	1	1	1	13
States/Areas Covered	CT, NJ, NY, MA, PA, VT	CT, NJ, NY, MA, PA, VT	CT, NJ, NY	Northeast	Northeast	Northeast	-
Population of Coverage Area	25,712,577	25,712,577	19,658,795	50,058,090	50,058,090	50,058,090	221,258,219

Challenging Incumbents (No. of Licenses Challenged)	Cingular AWS LLC (1), Cricket Licensee (Reauction) Inc. (1), Denali Spectrum License LLC (1), SpectrumCo LLC (1)	Cingular AWS LLC (1), Cricket Licensee (Reauction) Inc. (1), Denali Spectrum License LLC (1), MetroPCS AWS LLC (1), SpectrumCo LLC (1), T-Mobile License LLC (1)	Cingular AWS LLC (4), Cricket Licensee (Reauction) Inc. (2), Denali Spectrum License LLC (1), MetroPCS AWS LLC (1), SpectrumCo LLC (1), T-Mobile License LLC (8)	Cingular AWS LLC (1), Denali Spectrum License LLC (1), MetroPCS AWS LLC (1), SpectrumCo LLC (1), T-Mobile License LLC (1)	Cingular AWS LLC (1), Denali Spectrum License LLC (1), MetroPCS AWS LLC (1), SpectrumCo LLC (1), T-Mobile License LLC (1)	Cellco Partnership d/b/a Verizon Wireless (1), Cingular AWS LLC (1)	-
States/Areas Covered by Challenged Licenses	CT, NJ, NY, MA, PA, VT	CT, NJ, NY, MA, PA, VT	CT, NJ, NY	Northeast	Northeast	Northeast	-
Population of Coverage Area of Challenged Licenses	25,712,577	25,712,577	19,658,795	50,058,090	50,058,090	50,058,090	221,258,219

Table 8.
Bidding Profile of NTELOS Inc.

	BEA		**CMA**	**REAG**			
	B Block	**C Block**	**A Block**	**D Block**	**E Block**	**F Block**	**Total**
No. of Licenses Sought	0	3	15	0	0	0	18
States/Areas Covered	-	KY, NC, OH, VA, WV	KY, NC, OH, VA, WV	-	-	-	-
Population of Coverage Area	-	4,368,260	4,816,268	-	-	-	9,184,528
Challenging Incumbents (No. of Licenses Challenged)	-	Cingular AWS LLC (2), Cricket Licensee (Reauction) Inc. (1), SpectrumCo LLC (2)	Cingular AWS LLC (4), Cricket Licensee (Reauction) Inc. (3), T-Mobile License LLC (3)	-	-	-	-
States/Areas Covered by Challenged Licenses	-	NC, VA	NC, VA	-	-	-	-

Population of Coverage Area of Challenged Licenses	-	3,168,887	2,637,570	-	-	-	5,806,457

Table 9.
Bidding Profile of Wireless DBS LLC

	BEA		CMA	REAG			
	B Block	**C Block**	**A Block**	**D Block**	**E Block**	**F Block**	**Total**
No. of Licenses Sought	1	1	5	8	8	8	31
States/Areas Covered	CA, CT, MA, NJ, NY, PA, VT	CT, MA, NJ, NY, PA, VT	CA, DC, IL, MD, NY, NJ, PA, VA	Northeast, Southeast, Great Lakes, Mississippi Valley, Central, West, Alaska, Hawaii	Northeast, Southeast, Great Lakes, Mississippi Valley, Central, West, Alaska, Hawaii	Northeast, Southeast, Great Lakes, Mississippi Valley, Central, West, Alaska, Hawaii	-
Population of Coverage Area	34,824,383	25,712,577	69,648,766	281,421,906	281,421,906	281,421,906	974,451,444
Challenging Incumbents (No. of Licenses Challenged)	Cellco Partnership d/b/a Verizon Wireless (1), Cingular AWS LLC (1), Cricket Licensee (Reauction) Inc. (1), Denali Spectrum Holdings LLC (1), MetroPCS AWS LLC (1), SpectrumCo LLC (1)	Cellco Partnership d/b/a Verizon Wireless (1), Cingular AWS LLC (1), Cricket Licensee (Reauction) Inc. (1), MetroPCS AWS LLC (1), SpectrumCo LLC (1)	Cingular AWS LLC (5), Cricket licensee (Reauction) Inc. (5), Denali Spectrum Holdings LLC (2), MetroPCS AWS LLC (3), SpectrumCo LLC (5), T-Mobile License LLC (5)	Barat Wireless LP (2), Cingular AWS LLC (6), Cricket Licensee (Reauction) Inc. (3), Denali Spectrum Holdings LLC (2), MetroPCS AWS LLC (6), SpectrumCo LLC (7), T-Mobile License LLC (6)	Barat Wireless LP (2), Cingular AWS LLC (6), Cricket Licensee (Reauction) Inc. (5), Denali Spectrum Holdings LLC (3), MetroPCS AWS LLC (5), SpectrumCo LLC (7), T-Mobile License LLC (8)	Barat Wireless LP (2), Cingular AWS LLC (7), Cricket Licensee (Reauction) Inc. (6), Denali Spectrum Holdings LLC (3), MetroPCS AWS LLC (2), SpectrumCo LLC (7), T-Mobile License LLC (7)	-
States/Areas Covered by Challenged Licenses	CA, CT, MA, NJ, NY, PA, VT	CT, MA, NJ, NY, PA, VT	CA, DC, IL, MD, NY, NJ, PA, VA	Northeast, Southeast, Great Lakes, Mississippi Valley, Central, West, Alaska, Hawaii	Northeast, Southeast, Great Lakes, Mississippi Valley, Central, West, Alaska, Hawaii	Northeast, Southeast, Great Lakes, Mississippi Valley, Central, West, Alaska, Hawaii	-

Population of Coverage Area of Challenged Licenses	34,824,383	25,712,577	69,648,766	281,421,906	281,421,906	281,421,906	974,451,444

Table 11.
Wireless DBS LLC's National AWS Footprint and How Incumbents Blocked It

License	Market Name	Round of First Bid	Round of Last Bid	No. of Bids	Challenging Incumbents (Round of Entry)	Ultimate Winner of License (Round PWB)[32]
AW-REA001-F	Northeast	1	9	9	Cingular AWS LLC (1), MetroPCS AWS, LLC (1), SpectrumCo LLC (1), T-Mobile License LLC (1), Cricket Licensee (Reauction) Inc. (4), Cellco Partnership d/b/a Verizon Wireless (9)	Cellco Partnership d/b/a Verizon Wireless (16)
AW-REA002-F	Southeast	1	10	10	Cellco Partnership d/b/a Verizon Wireless (1), Cingular AWS, LLC (1), SpectrumCo LLC (1), T-Mobile License LLC (1), Cricket Licensee (Reauction) Inc. (4)	Cellco Partnership d/b/a Verizon Wireless (14)
AW-REA003-F	Great Lakes	1	11	9	Barat Wireless LP (1), Cellco Partnership d/b/a Verizon Wireless (1), Cingular AWS, LLC (1), Cricket Licensee (Reauction) Inc. (1), SpectrumCo LLC (1), T-Mobile License LLC (1)	Cellco Partnership d/b/a Verizon Wireless (14)
AW-REA004-F	Mississippi Valley	1	11	9	Barat Wireless LP (1), Cellco Partnership d/b/a Verizon Wireless (1), Cingular AWS, LLC (1), SpectrumCo LLC (1), T-Mobile License LLC (1), Cricket Licensee (Reauction) Inc. (4)	Cellco Partnership d/b/a Verizon Wireless (14)

AW-REA005-F	Central	1	11	10	Cellco Partnership d/b/a Verizon Wireless (1), Cingular AWS LLC (1), SpectrumCo LLC (1), T-Mobile License LLC (1), Cricket Licensee (Reauction) Inc. (3)	T-Mobile License LLC (15)
AW-REA006-F	West	1	9	8	Cellco Partnership d/b/a Verizon Wireless (1), Cingular AWS LLC (1), Cricket Licensee (Reauction) Inc. (1), MetroPCS AWS LLC (1), SpectrumCo LLC (1), T-Mobile License LLC (1)	T-Mobile License LLC (15)
AW-REA007-F	Alaska	1	2	2	-	MTA Communications, Inc. (119)
AW-REA008-F	Hawaii	1	2	2	Cingular AWS LLC (1), SpectrumCo LLC (1), T-Mobile License LLC (1)	T-Mobile License LLC (108)
AW-REA001-D	Northeast	1	11	7	SpectrumCo LLC (1), Cingular AWS LLC (9), MetroPCS AWS, LLC (9), T-Mobile License LLC (10)	MetroPCS AWS, LLC (18)
AW-REA002-D	Southeast	1	7	5	Cricket Licensee (Reauction) Inc. (1), MetroPCS AWS, LLC (1), SpectrumCo LLC (1)	T-Mobile License LLC (15)
AW-REA003-D	Great Lakes	1	8	6	MetroPCS AWS, LLC (1), SpectrumCo LLC (1), Barat Wireless LP (4), Cricket Licensee (Reauction) Inc. (10)	Denali Spectrum License, LLC (20)
AW-REA004-D	Mississippi Valley	1	8	6	MetroPCS AWS, LLC (1), SpectrumCo LLC (1), Cingular AWS, LLC (4), Barat Wireless LP (8)	T-Mobile License LLC (15)
AW-REA005-D	Central	1	8	6	MetroPCS AWS, LLC (1), SpectrumCo LLC (1), Cingular AWS LLC (10)	Cingular AWS LLC (12)
AW-REA006-D	West	1	8	5	SpectrumCo LLC (1), MetroPCS AWS LLC (6), Cingular AWS, LLC (9)	MetroPCS AWS LLC (14)

AW-REA007-D	Alaska	1	2	2	-	Spotlight Media Corp (147)
AW-REA008-D	Hawaii	1	2	2	SpectrumCo LLC (1)	SpectrumCo LLC (97)
AW-REA001-E	Northeast	1	11	7	T-Mobile License LLC (1), Cingular AWS LLC (9), MetroPCS AWS LLC (9), SpectrumCo LLC (9)	T-Mobile License LLC (17)
AW-REA002-E	Southeast	1	10	6	Cricket Licensee (Reauction) Inc. (1), T-Mobile License LLC (1), Cingular AWS, LLC (9), SpectrumCo LLC (11)	T-Mobile License LLC (19)
AW-REA003-E	Great Lakes	1	10	6	T-Mobile License LLC (1), Cricket Licensee (Reauction) Inc. (3), MetroPCS AWS, LLC (6), Barat Wireless LP (8), SpectrumCo LLC (11)	T-Mobile License LLC (19)
AW-REA004-E	Mississippi Valley	1	10	5	T-Mobile License LLC (1), Barat Wireless LP (8), Cricket Licensee (Reauction) Inc. (10)	Barat Wireless, L.P. (16)
AW-REA007-E	Alaska	1	2	2	-	American Cellular Corporation (152)
AW-REA008-E	Hawaii	1	2	2	T-Mobile License LLC (1), Cingular AWS LLC (8)	T-Mobile License LLC (117)
AW-CMA001-A	New York-Newark, NY-NJ	1	11	5	T-Mobile License LLC (1), Cingular AWS LLC (11)	T-Mobile License LLC (23)
AW-CMA003-A	Chicago, IL	4	4	1	T-Mobile License LLC (1)	T-Mobile License LLC (51)
AW-CMA004-A	Philadelphia, PA	4	4	1	T-Mobile License LLC (1)	Cricket Licensee (Reauction), Inc. (48)
AW-CMA007-A	San Francisco-Oakland, CA	10	10	1	T-Mobile License LLC (1)	T-Mobile License LLC (26)
AW-CMA008-A	Washington, DC-MD-VA	4	4	1	T-Mobile License LLC (1)	Cricket Licensee (Reauction), Inc. (38)
AW-BEA010-B	NYC-Long Is. NY-NJ-CT-PA-MA-	5	10	2	Cingular AWS LLC (5), MetroPCS AWS LLC (10), SpectrumCo	SpectrumCo (20)

	VT				LLC (11)	
AW-BEA010-C	NYC-Long Is. NY-NJ-CT-PA-MA-VT	7	10	2	Cingular AWS LLC (3)	MetroPCS AWS, LLC (41)

Table 12.
Patterns of Bidding by Incumbents Prior to and Post Wireless DBS LLC Withdrawal from Bidding on REAG F Block Spectrum

		AW-REA001-F	AW-REA002-F	AW-REA003-F	AW-REA004-F	AW-REA005-F	AW-REA006-F	Percent of Licenses Bid On
Round of PWB		16	14	14	14	15	15	-
Barat Wireless LP	**Prior**	0	0	6	7	0	0	33%
	Post	0	0	0	0	0	0	0%
Cellco Partnership d/b/a Verizon Wireless	**Prior**	1	6	8	6	10	8	100%
	Post	4	3	3	2	2	2	100%
Cingular AWS LLC	**Prior**	7	6	9	2	8	7	100%
	Post	0	0	2	0	0	0	17%
Cricket Licensee (Reauction) Inc.	**Prior**	7	7	7	4	6	6	100%
	Post	0	1	3	0	1	0	50%
Denali Spectrum License LLC	**Prior**	5	1	0	0	0	2	50%
	Post	0	0	0	0	0	0	0%
MetroPCS AWS LLC	**Prior**	7	0	0	0	0	5	33%
	Post	0	0	0	0	0	0	0%
SpectrumCo LLC	**Prior**	9	9	9	7	7	8	100%
	Post	0	0	1	0	0	0	17%
T- Mobile License LLC	**Prior**	7	8	7	7	7	6	100%
	Post	3	3	3	2	3	3	100%

Endnotes

[1] Peter Cramton and Jesse A. Schwartz, "Collusive Bidding in FCC Spectrum Auctions," working paper, University of Maryland, 1999; the paper was later published as "Collusive Bidding in FCC Spectrum Auctions," *Contributions to Economic Policy & Analysis*, I:1 (2002), article 11.

[2] A 1999 German spectrum auction provided further evidence of collusive allocations in open-bid, ascending auctions: Mannesmann and T-Mobil essentially negotiated a division of the blocks. *Viz*., P. Jehiel and B. Moldovanu, "A Critique of the Planned Rules for the German UMTS/IMT-2000 License Auction," working paper, University College London and University of Mannheim, 2000, and V. Grimm, F. Riedel, and E. Wolfstetter, "The Third Generation (UMTS) Spectrum Auction in Germany." *ifo Studien*, 48 (2002), 123–143.

[3] Paul Milgrom and Robert Weber, "The Theory of Auctions and Competitive Bidding", *Econometrica*, 50 (1982).

[4] Motty Perry and Philip J. Reny, "On the Failure of the Linkage Principle in Multi-Unit Auctions," *Econometrica*, 67 (1999). More recent scholarship has extended finding of failure of the "Linkage Principle" to a wider range of auction structures: Vijay Krishna, *Auction Theory* (San Diego, CA, 2002); Thierry Foucault and Stefano Lovo, "Linkage principle, Multi-dimensional Signals and Blind Auctions." working paper, HEC School of Management, 2003; S. Board, "Revealing Information in Auctions: The Efficiency Effect," working paper, University of Toronto, 2004.

[5] Interestingly, Verizon did not oppose anonymous bidding.

[6] *Communications Daily*, March 28, 2006.

[7] The author is particularly grateful to Dr. Jesse A. Schwartz who graciously shared algorithms developed for his analysis of the PCS D, E, and F auctions.

[8] M.S. Robinson, "Collusion and the Choice of Auction." *The RAND Journal of Economics*, 16 (1985), 141–145; George Mailath, George and Peter Zemsky, "Collusion in Second Price Auctions with Heterogeneous Bidders," *Games and Economic Behavior*, 3 (1991); F. Menezes, "Multiple-unit English Auctions," *European Journal of Political Economy*, 12 (1996), 671–684; R.J. Weber, "Making More from Less: Strategic Demand Reduction in the FCC Spectrum Auctions," *Journal of Economics and Management Strategy*, 6 (1997), 529–548; Richard Engelbrecht-Wiggans and Charles M. Kahn, "Low Revenue Equilibria in Simultaneous Auctions," working paper, University of Illinois, 1999; L. M. Ausubel and Peter Cramton, "Demand Reduction and Inefficiency in Multi-Unit Auctions," working paper, University of Maryland, 1999; Peter Cramton and Jesse Schwartz, "Collusive Bidding: Lessons from the FCC Spectrum Auctions," *Journal of Regulatory Economics*, 17 (2000); Robert C. Marshall and Michael J. Meurer, "The Economics of Bidder Collusion," in K. Chatterjee and W.F. Samuelson, eds., *Game Theory and Business Applications* (Norwell, MA., 2001); Sandro Brusco and Giuseppe Lopomo, Giuseppe, 2002. "Collusion via Signalling in Simultaneous Ascending Bid Auctions with Heterogeneous Objects, with and without Complementarities," *Review of Economic Studies*, 69:2 (2002).

[9] *Op. cit.*, 1.

[10] Peter Cramton and Jesse A. Schwartz, "Collusive Bidding in FCC Spectrum Auctions," working paper, University of Maryland, 1999; the paper was later published as "Collusive Bidding in FCC Spectrum Auctions," *Contributions to Economic Policy & Analysis*, I:1 (2004), article 11.

[11] *Ibid.,* 28.

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

[13] *Op. cit.,* 245-46. Cramton and Schwartz also make the point that both retaliatory bidding and sheer size had the deterrent effect, a point worth remembering when considering the asymmetrical capitalization of incumbents in most auctions.

[14] Ibid, 8-9.

[15] There were 176 20 MHz licenses in the Basic Economic Area B Block (BEA) and 176 10 MHz licenses in the 10 MHz Basic Economic Area (BEA) C Block.

[16] There were 734 20 MHz licenses in the Cellular Market Area A Block.

[17] This is the reason why even relatively small rates of retaliatory bidding can have considerable demand reduction effects.

[18] There is a myth about the prices fetched in the AWS-1 auction. The source of this error is a BIA Financial Network analysis of the auction which has been uncritically adopted by industry analysts and

which claims a mean dollar per MHz-pop value of $0.54. This analysis calculates the variable in the usual way (gross high bid/MHz/population of license area), then weights the results by population. It is unclear why this was done, since the initial calculation is weighted for population, and it has the effect of inflating the dollar per MHz-pop price means enormously,[18] because population relatively strongly correlated with high winning bids in the auction. BIA then took an unweighted average of the five inflated means ($0.41, $0.51, $0.43, $0.59, and $0.73, respectively) to arrive at the $0.54 per MHz-pop mean for the AWS-1 auction as a whole. When the mean is weighted by percent of licenses in each type (20 MHz CMA, 10 and 20 MHz BEA, and 10 and 20 MHz REAG), the auction's mean MHz-pop is $0.19.

[19] A two-tailed t-test assesses whether the means of two groups are statistically different from each other. A *p* value of 0.0125 indicates that 1.25 times out of a hundred you would find a statistically significant difference between the means by random chance even if there was none, i.e., a 98.75 percent chance that the significant difference is genuine.

[20] *See* "Written Ex Parte Statement of Dr. Gregory Rose on Behalf of NHMC, *et al.* in Opposition to the Proposed 'Compromise' on Anonymous Bidding," WT Docket No. 05-211/ AU Docket No. 06-33, April 5, 2006.

[21] Barat Wireless LP is primarily owned by U.S. Cellular Corporation.

[22] Denali Spectrum License LLC and Cricket Licensee (Reauction) are primarily owned by LEAP International Wireless, Inc.

[23] Two incumbents, Denali Spectrum Holdings LLC and MetroPCS AWS LLC, were challenged by other incumbents at relatively high rates. This appears to have been a consequence of similarities in underlying bidding profile and an epiphenomenon of the smaller package of licenses each bid on in attempting to block the targeted new entrants.

[24] The coverage populations are summed over the coverage population of each license; there is overlap in many cases, but since each license is unique this overlap become a measure of depth as well as breadth of coverage.

[25] Simon Wilkie, "Spectrum Auctions Are Not a Panacea: Theory and Evidence of Anti-Competitive and Rent-Seeking Behavior in FCC Rulemakings and Auction Design," WT Docket No. 07-16, April 26, 2007, 42.

[26] Alaska is anomalous in that Wireless DBS LLC made very little effort to acquire any of the REAG license blocks there. As in Hawaii, which is slightly less anomalous, Wireless DBS LLC made no bids on any Alaskan license after the second round. This probably reflects a decision to suspend bidding until the situation of licenses in the lower forty-eight states was resolved.

[27] High reserve prices have also been suggested as a remedy on the theory because the benefit from demand reduction decreases as reserve prices increase and high reserve prices reduce the number of rounds over which bidders can negotiate a collusive allocation at relatively low prices. The principal problem is that the FCC has historically been dreadful at setting reserve prices which match market valuations: in 36.21% of auctions licenses have failed to clear at reserve price even with FCC reductions of reserve price during bidding a commonplace (cf. Gregory F. Rose and Mark Lloyd, "The Failure of FCC Spectrum Auctions," Center for American Progress, 2006). It is difficult to see how such reserve prices can be fine-tuned to eliminate demand reduction without leaving substantial numbers of licenses uncleared at an auction's conclusion. Larger license sizes have also been recommended as conducive to retarding demand reduction on the grounds that larger licenses would attract higher prices. While larger licenses might retard demand reduction generally, it does not address the necessary condition for signaling and this solution ignores the chilling effect significant license size increases across the board would have on small bidder participation.

[28] Peter Cramton, "Spectrum Auctions," in M. Cave, S. Majumdar, and I, Vogelsang, eds., *Handbook of Telecommunications Economics* (Amsterdam, 2002), 605-639). The passage is a quotation from Cramton's and Schwartz's 2002 article.

[29] Paul Klemperer, *Auctions: Theory and Practice* (Princeton, 2004), 86-87.

[30] In Table 2 **boldfaced** numbers are rates of challenge two or more standard deviations from the mean of the challenging incumbent; targeted new entrants are **boldfaced** and challenged incumbents are *italicized*.

[31] In Table 4 **boldfaced** numbers are rates of challenge two or more standard deviations from the mean of the challenging targeted new entrant; challenged targeted new entrants are **boldfaced** and challenged incumbents are *italicized*.

[32] PWB is a technical abbreviation used by the FCC, meaing "purchased with bid."