

**ECONOMIC ANALYSIS OF PROPOSALS THAT WOULD RESTRICT PARTICIPATION
IN THE INCENTIVE AUCTION**

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I. Executive summary

- (1) This report analyzes proposals to restrict Verizon's and AT&T's participation in the Federal Communication Commission's (FCC's) upcoming Incentive Auction. My key conclusions are:

Foreclosure

- Proposals to restrict the participation of Verizon and AT&T in the Incentive Auction do not address any real world problem. The assertion that some smaller wireless operators are at risk of being foreclosed from the spectrum necessary for them to compete is inconsistent with those firms' own behavior, including their repeated decisions to forego opportunities to acquire low-frequency spectrum. Other evidence, including Sprint's and T-Mobile's marketing of unlimited usage plans, further belies the assertion that those operators face capacity constraints that could be exploited through a foreclosure strategy.
- Even if (despite the evidence to the contrary) a strategy by Verizon and AT&T to attempt to foreclose rivals were rational, implementing it would be difficult. A foreclosure strategy is particularly difficult to implement in the context of the Incentive Auction because higher bids on the part of buyers result in a greater quantity of spectrum being made available from sellers, thus increasing the costs of foreclosure. In addition, in an auction with anonymous bidding, it would be difficult for AT&T and Verizon to know whether they are bidding against the foreclosure targets or against one another. Furthermore, even if a foreclosure strategy were feasible, Verizon and AT&T would each have an incentive to "free ride" on the other's willingness to pay supra-competitive prices for spectrum.

Bidding Restrictions

- Based on the economics literature, empirical data from past FCC auctions, and a model of a two-sided auction mechanism, I conclude that restricting Verizon and AT&T in the Incentive Auction would put at risk its twin priorities of raising significant revenue and reallocating a substantial amount of spectrum from broadcast to mobile wireless services.
 - My simulations of past auctions show that, without Verizon and AT&T, revenue in the 700 MHz auction would have been 45% lower and revenue in the AWS-1 auction would have been 16% lower.
 - I also analyze bidding restrictions that would not fully exclude Verizon or AT&T, such as spectrum aggregation caps. The evidence indicates that any restriction that causes a material reduction in the participation of Verizon and AT&T risks a significant reduction in auction revenue and a failure of the auction.
- Parties supporting auction restrictions speculate that they might actually increase revenue by ensuring that smaller firms are not discouraged from participating. But they support that conjecture only with hypothetical examples. Their theories are undermined by the empirical evidence, including the historical fact that smaller firms routinely compete successfully in auctions despite the unrestricted presence of larger bidders. Although Sprint's and T-Mobile's economists speculate that restricting larger bidders might encourage small bidders to participate more robustly, they do not assert that their own clients would choose not to participate because of the unrestricted presence of Verizon and AT&T.

- I also analyze T-Mobile's complex proposal to successively ease the proposed restrictions, after each round and on a market-by-market basis, if the restrictions cause the auction to fall short of an unspecified revenue target. That proposal would not avoid the revenue-suppressing effects of the auction restrictions. In addition, the added complexity and incentives created for strategic bidding threaten to distort auction outcomes.
- (2) Both the risks and costs of auction failure are further heightened by the overall complexity of the Incentive Auction and the significant difficulties associated with reallocating spectrum from broadcast to mobile wireless at a later date, if it is not reallocated as part of the Incentive Auction. Therefore, in the absence of evidence that anticompetitive foreclosure is likely (which has not been presented by any party), the FCC should avoid imposing restrictions on participation in the Incentive Auction. And if the FCC nevertheless believes that evidence of a foreclosure risk does exist, it can be addressed through other policies, such as build-out requirements, that do not present the same risk of auction failure.

I.A. Empirical evidence and economic theory contradict assertions that there is a risk of foreclosure if all bidders are permitted to participate fully in the Incentive Auction

- (3) There is no basis for assertions that Sprint or T-Mobile has been foreclosed from acquiring low-frequency spectrum. The evidence points instead to a *choice* by Sprint and T-Mobile not to compete for low-frequency spectrum, rather than foreclosure from access to it. These carriers have not purchased it in the secondary market, where there were 2,153 licenses available since 2007: Sprint bought none and T-Mobile bought only one. And they did not purchase it in the FCC's recent auction of low-frequency spectrum, the 700 MHz auction in 2008, despite the claimed need for the low-frequency spectrum on offer there. It is particularly notable that Sprint and T-Mobile, despite the claimed need for low-frequency spectrum in order to build out rural areas, have acquired *no* such spectrum in rural markets despite numerous opportunities to do so.
- (4) Evidence on pricing plans is inconsistent with a finding that Verizon and AT&T have an incentive to "warehouse" spectrum in order to keep T-Mobile and Sprint capacity-constrained. Sprint and T-Mobile both tend to offer plans with unlimited data usage, and T-Mobile explicitly touts its network as being less congested than that of its competitors. By contrast, Verizon and AT&T tend to offer plans that require incremental payments for data use beyond a specified level. That pattern is the opposite of what would be expected under theoretical conditions where the smaller national competitors' access to a key input is constrained.
- (5) Head-to-head competition between AT&T and Verizon where no other bidders were present accounted for more than \$4.2 billion in revenue during the 700 MHz auction. Those dollars would

not have been spent by Verizon and AT&T if the purpose of their bidding had been simply to keep spectrum out of the hands of other operators.

- (6) Concerns that Verizon and AT&T might pursue a foreclosure strategy against Sprint and T-Mobile also ignore a number of key features of the market and the Incentive Auction. First, the FCC can directly address the issue using tools that would not create a risk of auction failure, such as imposing build-out requirements on licenses won in the Incentive Auction. Second, free-rider issues make foreclosure less likely because Verizon and AT&T would each prefer that the other incur the costs of such a strategy. Third, anonymous auction design makes a foreclosures strategy difficult and costly to implement. Fourth, a foreclosure strategy is particularly difficult to implement in the context of an incentive auction because higher bids on the part of buyers result in a greater quantity of spectrum being made available from sellers. Fifth, the market for mobile wireless services does not appear to be sufficiently concentrated to support the profitability of a foreclosure strategy.

I.B. The economics literature confirms that bidding restrictions are expected to reduce auction revenue

- (7) The theoretical literature concludes that excluding bidders reduces auction revenue. In addition, empirical evidence on the effects of bidding restrictions at U.S. Forest Service timber auctions shows that set-asides reduced auction revenue and the amount of timber sold. The literature also identifies key ways in which a two-sided auction differs from the more familiar one-sided auction. In particular, a two-sided auction can be more sensitive to the exclusion of buyers than a one-sided auction.
- (8) Thus, the literature indicates that regulators should expect reductions in revenue and the quantity transacted as a result of restrictions on bidders at the Incentive Auction. In addition, a reduction in the amount of spectrum transacted in the Incentive Auction means that less spectrum will be reallocated from broadcast use to mobile wireless services. This potentially has broader economic consequences given that there appears to be a consensus that the wireless industry as a whole is likely to suffer from a spectrum shortage as data usage continues to increase. Failure to promote the FCC's goal in its National Broadband Plan to repurpose a substantial amount of spectrum for wireless operations could lead to higher prices for consumers, reduced quality of services, and stalled innovation.¹

¹ See, e.g., National Broadband Plan: Connecting America at p.xii.

I.C. Bidding restrictions in past FCC auctions would have substantially reduced revenue

- (9) I simulate the effects of bidding restrictions in two previous FCC auctions, Auction 66, the AWS spectrum auction, and Auction 73, the 700 MHz auction. The simulation results show that bidding restrictions at these past FCC auctions would have lowered revenues and prices and negatively affected efficiency. The results show that, in the absence of Verizon and AT&T, auction revenues would have been 16% lower in the FCC's 2006 AWS spectrum auction and 45% lower in the 2008 700 MHz spectrum auction. In the AWS auction, T-Mobile would have benefited from a substantial subsidy if bidding restrictions had been imposed on Verizon and AT&T: in the simulation, the average price per MHz*Pop that T-Mobile pays for the licenses it wins falls by 18%.
- (10) I also analyze the impact of spectrum share caps that, as proposed by some parties, fall short of outright exclusion, and find revenue reductions of 15% in the AWS spectrum auction and of 41% in the 700 MHz auction. While the simulation of such caps in past auctions cannot be expected to provide precise estimates of the impact of such policies in the Incentive Auction, the empirical evidence indicates that any policy that leads to a significant reduction in the participation of Verizon and AT&T risks a significant negative revenue impact. The larger the reduction in participation, the larger will be the negative impact on revenue. As these simulations show, the loss of Verizon and AT&T as active competitors in the auction leads to substantial reductions in revenue.

I.D. Bidding restrictions in the Incentive Auction would risk auction failure

- (11) I simulate the effects of bidding restrictions in a two-sided auction using a theoretical model of buyer and seller behavior in a two-sided auction, one where sellers must be enticed to give up their assets by the magnitude of the buyers' bids. This model illustrates how the risk of auction failure is heightened where bidding restrictions are imposed in the context of a two-sided auction.
- (12) Bidding restrictions would reduce the maximum possible revenue and the maximum possible quantity of repurposed spectrum that can be achieved. In fact, the entire set of possible outcomes is shifted in the direction of lower revenue and a lower quantity of repurposed spectrum. If a minimum combination of revenue and quantity is required in order for the auction to succeed, then the elimination of two buyers could make that objective impossible to achieve, causing the auction to fail.
- (13) Moreover, it is my understanding that there may be a minimum amount of spectrum the FCC will need to clear in the reverse auction in order to offer spectrum in the forward auction that is attractive to a majority of wireless operators. Specifically, it is my understanding that in any market where less than 72 MHz of spectrum is available to be sold to wireless operators, it may be challenging or even

impossible to configure a technically viable band plan featuring paired spectrum. To the extent that technical considerations dictate a quantity floor below which the Incentive Auction may not fall, the risk that auction restrictions would cause auction failure is increased.

II. Introduction and scope of submission

- (14) I have been asked by Verizon to evaluate the claim that Verizon (possibly in conjunction with AT&T) has an incentive and ability to foreclose Sprint and T-Mobile from gaining access to low-frequency spectrum through the FCC's upcoming Incentive Auction, which is meant to reallocate spectrum from broadcasters to providers of mobile wireless services.² In addition, I have been asked to analyze the likely effects of some of the proposals to limit Verizon's and AT&T's participation in the Incentive Auction.
- (15) A number of parties argue in submissions to the FCC that, because of purported concerns about foreclosure of Sprint, T-Mobile, or other wireless operators, the FCC should limit Verizon's and AT&T's participation in the Incentive Auction.³ However, the principal goals of the Incentive Auction are to reallocate spectrum to a higher-valued use and to raise revenue to fund other priorities. Therefore, limiting participation in the Incentive Auction by two buyers that have shown that they place a high value on spectrum puts the goals of the Incentive Auction at risk.

II.A. Relevant qualifications

- (16) I am the Robert A. Bandeen Professor of Economics at the Fuqua School of Business at Duke University. In addition, I am a Partner at the economic consulting firm Bates White, LLC. I received my PhD in Economics from Northwestern University. I served as Chief Economist for the FCC from August 2005 to August 2006 and served as a consultant to the Wireless Telecommunications Bureau of the FCC from August 2006 to August 2007. I have published numerous articles on various industry organization topics and on auction theory, and have recently focused on the economics of two-sided auctions. My CV is attached as Appendix A.

² For background on the FCC's Incentive Auction, see <http://www.fcc.gov/incentiveauctions>. For additional discussion, see Simon Loertscher, Leslie M. Marx, and Tom Wilkening (2013), "A Long Way Coming: Designing Centralized Markets with Privately Informed Buyers and Sellers," Working Paper, Duke University, available at <https://faculty.fuqua.duke.edu/~marx/bio/papers/incentiveauction.pdf>. An early proposal suggesting that the FCC put in place an incentive auction type of mechanism was put forward by Evan Kwerel and John Williams (2002), "A Proposal for a Rapid Transition to Market Allocation of Spectrum," OPP Working Paper No. 38, Federal Communications Commission.

³ See, e.g., U.S. Department of Justice, "Ex Parte Submission of the United States Department of Justice," WT Docket No. 12-269, April 11, 2013 (DOJ ex parte).

- (17) My opinions are based on my training and experience as an economist, including my experience working with the FCC, and my analysis of the available evidence and data.

II.B. Background and scope of analysis

- (18) In 1993, the U.S. Congress directed the FCC to design and implement auctions to assign spectrum licenses to providers of mobile wireless services. Although nothing like that had been done before, the first auction was held in 1994, and since then the FCC has held more than 80 auctions, issued more than 36,000 licenses, and raised more than \$50 billion for the United States Treasury.⁴
- (19) In 2012, the U.S. Congress directed the FCC to design and implement a new type of auction. The upcoming Incentive Auction will create a centralized market for the exchange of spectrum licenses in the 600 MHz frequency band from broadcasters to providers of mobile wireless services.
- (20) The authorizing legislation for the Incentive Auction states that, in order for any transactions to occur, the sale of licenses to providers of wireless services must raise funds sufficient to cover: (i) the accepted bids of the television broadcasters, (ii) the FCC's out-of-pocket costs of conducting the auction, and (iii) the expected reimbursement costs of broadcasters and certain other parties associated with the license reassignments occurring as part of the auction.⁵ The legislation authorizing incentive auctions does not explicitly require the FCC to raise any additional revenue, but it does state that any additional revenue shall be transferred to the Public Safety Trust Fund for various enumerated purposes.⁶ Statements by members of Congress and FCC Commissioners indicate that the auction is expected to generate sufficient revenue to fund the FirstNet public safety network.⁷
- (21) At the same time, the Department of Justice (DOJ) and various parties to the *Spectrum Holdings* and *Incentive Auctions* proceedings have expressed concerns about allowing AT&T and Verizon to

⁴ Congressional Hearing on "Keeping the New Broadband Spectrum Law on Track" (U.S. House Energy and Commerce Committee, 12 Dec. 2012), statement of FCC Commissioner Jessica Rosenworcel.

⁵ Public Law 112-96, Section 6403(c)(2)(B), <http://www.gpo.gov/fdsys/pkg/PLAW-112publ96/pdf/PLAW-112publ96.pdf>.

⁶ See § 6403(d)(4)(A).

⁷ In Congressional Hearings on "Keeping the New Broadband Spectrum Law on Track" (U.S. House Energy and Commerce Committee, 12 Dec. 2012), FCC Commissioner Ajit Pai argued that if the incentive auction did not yield any net revenues, "That would mean no money for the First Responder Network Authority (FirstNet) to build out a nationwide, interoperable public safety broadband network; no money for state and local first responders; no money for public safety research; no money for deficit reduction; and no money for next-generation 911 implementation. Most of the problem stems from the structure of the proposed auction. The only closing condition set forth in the NPRM is that the revenues from the forward auction must cover the costs of the reverse auction." In the question-and-answer portion of the hearing, the FCC Commissioners were asked, "Should the commission ensure that the auction raises \$7b [for a nationwide interoperable public safety network]?" The responses were: "Pai: Yes, we should focus on maximizing revenue. Rosenworcel: Yes, absolutely. Clyburn: Absolutely. McDowell: Yes. Genachowski: Yes."

acquire spectrum licenses at the Incentive Auction.⁸ DOJ expressed particular concerns that Verizon and AT&T might acquire the low-frequency spectrum in rural areas only to hamper the ability of other carriers to compete in those markets. DOJ argues that low-frequency spectrum is particularly important for providing coverage in rural areas and Sprint and T-Mobile have “virtually none.”⁹

- (22) Assistant Attorney General Bill Baer later clarified in testimony to the Senate Judiciary Committee that the DOJ’s submission was designed to “urge the FCC... to take a look ... at whether or not the playing field is already tilted in favor of big guys who may or may not – we were not making a factual judgment -- ... [be] using what they already have and use that as a factor in deciding what rules to set in the auction.”¹⁰
- (23) Nonetheless, DOJ states that, “The Commission’s policies, particularly regarding auction of new low-frequency spectrum, can potentially improve the competitive landscape by preventing the leading carriers from foreclosing their rivals from access to low-frequency spectrum.”¹¹ It goes on to say, “[f]or instance, rules that ensure that the two smaller nationwide carriers are not foreclosed from access to more spectrum, and particularly low-frequency spectrum, could benefit consumers. Auction rules of this nature would ensure the smaller nationwide networks, which currently lack substantial low-frequency spectrum, would have an opportunity to acquire it.”¹²
- (24) In addition, in reply comments to the FCC on the design of the Incentive Auction, other commenters suggest the imposition of rules that would restrict the acquisition of additional spectrum by certain firms.¹³
- (25) As I show in this report, there is substantial conflict between the desire to raise revenue and reallocate spectrum through the Incentive Auction and the proposals to restrict the ability of Verizon and AT&T to compete in the auction. Such restrictions would potentially overcomplicate an already complex auction and put at risk achieving the dual goals of raising revenue and reallocation of spectrum. In addition, I show that historical bidding behavior indicates that restrictions on Verizon and AT&T are

⁸ DOJ ex parte.

⁹ DOJ ex parte at p.14.

¹⁰ Senate Judiciary Hearing, April 16, 2013, available at <http://www.judiciary.senate.gov/resources/webcasts/index.cfm>.

¹¹ DOJ ex parte at p.14.

¹² DOJ ex parte at p.23.

¹³ As reported in the communications trade press, “[a]mong the areas of continuing disagreement is whether the FCC should impose a cap on the ability of Verizon Wireless and AT&T to buy spectrum in the auction.” (“Sharp Disagreements Remain on Incentive Auction Rules,” *Communications Daily*, March 15, 2013) See, for example, the comments by T-Mobile: “One of the strongest deterrents to widespread participation in the 600 MHz auction is the prospect that bidding will be pointless if the nation’s two largest carriers – each of which has a market capitalization roughly ten times that of its next largest competitor – are given an unfettered ability to acquire all of the spectrum offered. Most commenters, therefore, support imposing a cap on spectrum acquisitions....” (Reply Comments of T-Mobile USA, Inc., GN Docket No. 12-268, March 12, 2013, pp.iv–v, available at <http://apps.fcc.gov/ecfs/document/view?id=7022130363>, accessed March 20, 2013) Other examples include the reply comments of the Competitive Carriers Association and Cellular South, Inc. in the same docket.

unlikely to substantially affect the allocation of licenses in rural areas, which appeared to be the key concern of DOJ.

III. There is no evidence that Sprint and T-Mobile have been foreclosed from access to low-frequency spectrum

- (26) Throughout this submission, I define low-frequency spectrum as spectrum that is at a frequency below one GHz.¹⁴ Data on the availability of low-frequency spectrum—both at auction and on the secondary market—are relevant for two reasons. First, to the extent that there are significant opportunities for wireless operators to acquire low-band spectrum through vehicles other than the Incentive Auction, such firms have the ability to bypass any theoretical “foreclosure” by Verizon and AT&T. Second, assertions that Sprint’s and T-Mobile’s ability to compete are reduced if they are not guaranteed access to low-frequency spectrum in the Incentive Auction can be tested against the conduct of these carriers in pursuing recent opportunities to acquire such spectrum.
- (27) I conclude, based on the empirical evidence, that the existence of a liquid market for low-frequency spectrum undercuts the assertion that there is a risk that AT&T and Verizon could foreclose rivals from such spectrum by buying up all available spectrum. I also conclude that the behavior of Sprint and T-Mobile, who have consistently failed to purchase low-frequency spectrum even when given numerous recent opportunities to do so, undercuts the assertion that either of those firms is at risk of being “foreclosed” from an input that is crucial to their ability to compete.

III.A. Sprint and T-Mobile were not foreclosed from acquiring spectrum in the 700 MHz and AWS spectrum auctions

III.A.1. 700 MHz Auction

- (28) The 2008 700 MHz auction was a large, relatively recent auction where the FCC auctioned 80 MHz of low-frequency (700 MHz) spectrum. It concluded in March 2008. Licenses sold in the 700 MHz auction can be used for mobile wireless services, including voice and mobile broadband, among other things.
- (29) Neither T-Mobile nor Sprint participated in the 700 MHz auction. By contrast, Verizon and AT&T, along with 99 other entities, actively participated. That 99 other entities participated is evidence that Verizon’s and AT&T’s participation in that auction did not discourage other interested buyers from bidding in the auction.

¹⁴ This is a common definition of “low frequency” in this context as noted in the DOJ ex parte at p.12.

- (30) It is useful to focus on the 700 MHz B-block licenses because these licenses cover areas the size of Cellular Market Areas (CMA) and thus can be easily defined as rural or non-rural.¹⁵ As reported in Figure 1, the majority of rural CMA-level licenses (72% in terms of numbers of licenses and 62% in terms of MHz*POPs¹⁶) were won by entities other than Verizon and AT&T.¹⁷ Thus, DOJ’s concern that Verizon and AT&T may foreclose other buyers of the low-frequency spectrum in rural areas is misplaced.

Figure 1 Number of B-block licenses won by top bidders in rural and non-rural CMAs in 700 MHz Auction

Bidder	Non-Rural		Rural	
	Licenses	MHz*POPs	Licenses	MHz*POPs
AT&T	150	1,881	77	229
Verizon	34	489	43	66
Qualcomm	1	2	2	3
Frontier (Dish)	0	0	0	0
T-Mobile (chose not to participate)	0	0	0	0
SpectrumCo (Sprint; chose not to participate)	0	0	0	0
Other	118	261	303	485
Total	303	2,634	425	783

Source: Calculations based on the FCC data and documentation.

III.A.2. AWS spectrum auction

- (31) In order to further evaluate claims that Sprint and T-Mobile have been foreclosed from acquiring spectrum suitable to expand coverage in rural areas, I analyze data from the 2006 AWS spectrum auction. The AWS spectrum auction, referred to as the “AWS-1 Auction,” was another large, relatively recent auction. It concluded in September 2006. Licenses sold in the AWS-1 spectrum auction can be used for mobile wireless services, including voice and mobile broadband. In this section, I focus on the AWS-1 A-block licenses, which are 20 MHz licenses defined over the 734 CMAs. It is useful for the purposes of this section to focus on the A-block licenses because CMA-sized areas can more easily be defined as either rural or non-rural.

¹⁵ In fact, the FCC identifies certain CMAs as rural areas.

¹⁶ The term “MHz-POPs” is defined as the product of the number of megahertz associated with a license and the population of the license’s service area, both of which affect the value of a license. Because trades can involve licenses of different sizes, both in terms of MHz and population coverage, an examination of the MHz*POP associated with trades provides additional information.

¹⁷ 72% is calculated by dividing the number of rural licenses won by participants other than Verizon and AT&T (305) by the total number of rural licenses (425). Similarly 62% is calculated by dividing 488 by 783.

- (32) Figure 2 reports the number and MHz*POPs of A-block licenses won by bidder broken down by rural and non-rural CMAs. The vast majority of these rural licenses (96% in terms of numbers of licenses and 95% in terms of MHz*POPs) were won by an entity other than Verizon, AT&T, T-Mobile, or Sprint. This suggests that Sprint and T-Mobile had an opportunity to acquire additional spectrum that would have expanded their rural coverage, but chose not to, even though Verizon and AT&T were not actively bidding on these licenses themselves either to acquire the spectrum or to keep it out of the hands of Sprint and T-Mobile.

Figure 2 Number of A-block licenses won by top bidders in rural and non-rural CMAs in AWS spectrum auction

Bidder	Non-Rural		Rural	
	Licenses	MHz*POPs	Licenses	MHz*POPs
T-Mobile	83	1,827	10	47
Cricket	38	715	35	136
AT&T	20	769	1	10
Verizon	2	11	5	10
SpectrumCo (Sprint)	0	0	0	0
Other	160	1,063	358	1,065
Total	303	4,384	409	1,268

Source: Calculations based on the FCC data and documentation.

III.B. Evidence from secondary market transactions shows that Sprint and T-Mobile have not been foreclosed

- (33) The availability of low-frequency spectrum on the secondary market would make it difficult for Verizon and AT&T to implement a successful foreclosure strategy at the Incentive Auction. AT&T and Verizon cannot prevent other providers from purchasing low-frequency (or any other) spectrum on the secondary market, unless they stand ready to purchase all or most of the available supply—and the evidence shows that they have not.
- (34) In addition, past secondary market transactions suggest that Sprint and T-Mobile have not been particularly interested in acquiring low-frequency spectrum—a fact that undercuts the assertion that they are at risk of being foreclosed.
- (35) Verizon gave me data, taken from the publicly available sources, on all of the assignment and transfer applications that the FCC received from January 8, 2007, to January 30, 2013. These transactions were consummated between February 16, 2007, and May 10, 2013. I use these data to investigate whether the empirical evidence supports the claim that Sprint, T-Mobile, or other wireless operators have not had opportunities to substantially increase their holdings of low-frequency spectrum.

- (36) The secondary market transactions data contain 5,153 spectrum trades.¹⁸ Eighty-eight percent of these transactions (4,510 out of 5,153) involved the transfer of the whole license. In the remaining 12% of transactions, the license was partitioned or disaggregated. When only one part of a license is transferred, the database does not report the fraction of the total licensed spectrum that was traded.
- (37) Figure 3 reports the number of whole and partial license transactions and the MHz*POPs million¹⁹ transacted as a part of whole license transfers. Because only 12% of transactions involved the partial assignment of a license and because the data do not specify the size of the partial assignment, I exclude these transactions from my analysis of secondary market transactions.

Figure 3 Secondary market transactions by band, January 2007–May 2013

Band	Counts of trades			MHz*POP (millions) traded, whole license trades only
	Whole license	Partial assignment	Total	
Cellular	1,110	1	1,111	6,360
Lower 700 MHz	984	56	1,040	7,091
Upper 700 MHz	2	0	2	16
<i>sub-total: below 1 GHz</i>	<i>2,096</i>	<i>57</i>	<i>2,153</i>	<i>13,466</i>
PCS	1,547	334	1,881	41,476
AWS	804	249	1,053	17,684
WCS	63	3	66	7,171
<i>subtotal: above 1 GHz</i>	<i>2,414</i>	<i>586</i>	<i>3,000</i>	<i>66,331</i>
Total	4,510	643	5,153	79,797

Source: Calculations based on FCC data and documentation.

III.B.1. Sprint and T-Mobile buy and sell spectrum in the secondary market

- (38) By looking at all transactions, not just low-frequency transactions, I establish that Sprint and T-Mobile actively participated in the secondary market, engaging in approximately the same number of buy transactions as sell transactions. That active participation suggests that Sprint and T-Mobile were able to acquire useful spectrum through this channel, but as I show below, they did not take advantage

¹⁸ I excluded 23 internal trades between two entities both under Verizon's control (2) or AT&T's control (21).

¹⁹ Because trades can involve licenses of different sizes, both in terms of MHz and population coverage, an examination of the MHz*POP associated with trades provides additional information.

of the secondary market to acquire low-frequency spectrum. Figure 18 in Appendix B reports the number of transactions by buyer and seller.

- (39) As shown in Figure 4 below, the evidence in terms of MHz*POPs traded (based on the 4,510 trades involving whole licenses) shows that both Sprint and T-Mobile were net buyers of spectrum in secondary market transactions, including purchases of spectrum from Verizon and AT&T. Furthermore, the data show that Sprint and T-Mobile could have purchased an additional 24,233 million MHz*POPs that spectrum holders other than Verizon and AT&T put up for sale. (These 24,233 million MHz*POPs correspond roughly to an 80 MHz license covering the entire United States.) Figure 4 shows that T-Mobile was able to increase its spectrum holdings substantially through secondary market transactions and that it could have purchased about six times more from sellers other than Verizon and AT&T than it decided to buy. (T-Mobile purchased 4,180 million MHz*POPs from “Other” sellers, but 24,233 million MHz*POPs sold by those other sellers were purchased by “Other” buyers.) The fact that Sprint only purchased 304 out of 24,233 million MHz*POPs from “Other” sellers suggests that although the secondary market was relatively active across most commercial spectrum bands, Sprint failed to take advantage of opportunity to acquire spectrum. The evidence from these secondary market transactions does not support claims that Sprint and T-Mobile have been anticompetitively foreclosed from acquiring spectrum.

Figure 4 MHz*POPs traded, all bands, January 2007–May 2013 (whole licenses only)

MHz*POP (millions) traded		Buyer					Total
		Verizon	ATT	T-Mobile	Sprint	Other	
Seller	Verizon		2,609	593	47	415	3,664
	ATT	629		1,297	4	431	2,360
	T-Mobile	1,914	1,169		20	343	3,447
	Sprint			22			22
	Other	19,298	22,289	4,180	304	24,233	70,303
	Total	21,841	26,068	6,092	375	25,422	79,797
<i>buy/sell ratio</i>		<i>5.96</i>	<i>11.04</i>	<i>1.77</i>	<i>16.82</i>	<i>0.36</i>	

Source: Calculations based on FCC data and documentation.

III.B.2. Neither T-Mobile nor Sprint has chosen to acquire low-frequency spectrum in the secondary market despite significant opportunities to do so

- (40) Since January 2007, there have been 2,153 transactions of low-frequency spectrum. T-Mobile bought one license and Sprint did not buy any.²⁰ Although Verizon and AT&T have been active buyers of

²⁰ T-Mobile bought a 25 MHz Cellular A license from SunCom Wireless Holdings covering CMA 629 (South Carolina 5 – Georgetown) where about 375,000 people currently reside. This was a part of T-Mobile’s acquisition of SunCom Wireless Holdings, Inc. that was announced in September 2007 and consummated in February 2008. In addition to one 25 MHz Cellular A license, T-Mobile also received 27 PCS licenses as part of the acquisition.

low-frequency spectrum, a significant proportion of the spectrum transacted did not involve Verizon or AT&T and thus could not have been subject to foreclosure by Verizon and AT&T.

- (41) In particular, focusing on the 2,096 low-frequency transactions that involved the transfer of a whole license, Figure 5 shows that—at a minimum—Sprint or T-Mobile could have been the buyer in 729 transactions when the buyer and seller were firms other than Verizon or AT&T. Figure 6 reports the quantities of low-frequency spectrum transacted in MHz*POPs rather than in numbers of transactions. Approximately thirty percent of the MHz*POPs of low-frequency spectrum transacted (3,691 million out of 12,832 million) were sold and purchased by a firm other than Verizon or AT&T and thus could not have been subject to foreclosure by Verizon or AT&T; this is roughly the same MHz*POPs as a 12 MHz license covering the entire United States. This evidence supports the conclusion that Sprint and T-Mobile have had opportunities to purchase low-frequency spectrum but have chosen not to.

Figure 5 Number of transactions of low-frequency whole licenses, January 2007–May 2013

Counts of trades		Buyer					Total
		Verizon	ATT	T-Mobile	Sprint	Other	
Seller	Verizon	n/a	81	0	0	79	160
	AT&T	4	n/a	0	0	1	5
	Other	450	751	1	0	729	1,931
	Total	454	832	1	0	809	2,096

Source: Calculations based on FCC data and documentation.

Figure 6 MHz*POPs of low-frequency spectrum transacted from January 2007 to May 2013 (whole licenses only)

MHz*POP (millions) traded		Buyer					Total
		Verizon	ATT	T-Mobile	Sprint	Other	
Seller	Verizon	n/a	207	0	0	402	609
	AT&T	23	n/a	0	0	2	25
	Other	2,726	6,406	9	0	3,691	12,832
	Total	2,749	6,613	9	0	4,095	13,466

Source: Calculations based on FCC data and documentation.

- (42) Verizon offered for sale all of its licenses in two blocks of the Lower 700 MHz band in 2013. This spectrum could have provided significant coverage in low-frequency spectrum for T-Mobile or Sprint, but neither company bought any of these licenses. The CFO of Deutsche Telekom said, “We

are not interested in 700 megahertz spectrum at this time [...] [T]his spectrum is nothing which would be attractive for us.”²¹

III.B.3. Sprint and T-Mobile have failed to act on opportunities to purchase low-frequency spectrum in rural areas

- (43) In the previous section, I show that there were opportunities for firms to purchase low-frequency spectrum on the secondary market, but that Sprint and T-Mobile did not take advantage of those opportunities. The evidence shows that they passed up these opportunities even in rural areas. This is noteworthy because DOJ has indicated a particular concern about potential foreclosure in rural markets, where low-frequency spectrum can facilitate deployment of wireless service with fewer cell sites because of its ability to propagate signals further.
- (44) The 2007-2013 data show that there were significant opportunities to purchase low-frequency spectrum in rural areas, which the FCC defines as areas where population density is currently below 100 inhabitants per square mile.²² According to the transactions data, Sprint and T-Mobile made *no* purchases of low-frequency spectrum in rural areas.

²¹ Q1 2012 Investor call (May 10, 2012).

²² “We establish a baseline definition of ‘rural area’ as those counties (or equivalent) with a population density of 100 persons per square mile or less, based upon the most recently available Census data.” *Facilitating the Provision of Spectrum-Based Services to Rural Areas and Promoting Opportunities for Rural Telephone Companies to Provide Spectrum-Based Services*, Report and Order, 19 FCC Rcd 19078, at ¶¶ 11, 79 (2004).

- (45) Figure 7 and Figure 8 below report transactions of low-frequency spectrum in rural areas. A significant proportion of the transactions involves neither Verizon nor AT&T as either the buyer or seller and thus could not have been subject to anticompetitive foreclosure by either. Yet of these 469 low-frequency licenses sold in rural areas, Sprint and T-Mobile bought none.

Figure 7 Number of transactions of low-frequency rural licenses traded, January 2007–May 2013 (whole licenses only)

Counts of trades		Buyer					Total
		Verizon	ATT	Sprint	T-Mobile	Other	
Seller	Verizon	n/a	74	0	0	53	127
	ATT	1	n/a	0	0	1	2
	Other	311	374	0	0	469	1,154
	Total	312	448	0	0	523	1,283

Source: Calculations based on FCC data and documentation.

Figure 8 Rural MHz*POPs of low-frequency spectrum transacted January 2007–May 2013 (whole licenses only)

MHz*POP (millions) traded		Buyer					Total
		Verizon	ATT	Sprint	T-Mobile	Other	
Seller	Verizon	n/a	176	0	0	171	347
	ATT	3	n/a	0	0	2	5
	Other	1,092	1,603	0	0	1,537	4,232
	Total	1,095	1,778	0	0	1,710	4,583

Source: Calculations based on FCC data and documentation.

- (46) There may be limitations to secondary market opportunities, and engaging in a sequence of small secondary market transactions may not be attractive for a carrier because of the risk that the carrier may be unable to purchase sufficient licenses at attractive prices to support its business plan. But T-Mobile’s and Sprint’s failures to make any meaningful attempts to acquire low-frequency spectrum, particularly rural low-frequency spectrum, suggest that they have chosen to target other bands of spectrum, not that they have been foreclosed. And the active secondary market for spectrum, including for rural low-frequency spectrum, would make it difficult for Verizon and AT&T to successfully execute a foreclosure strategy in the future.

III.C. Evidence from pricing plans suggests a pattern of capacity constraints that makes foreclosure unlikely

- (47) DOJ states that, “[a]bsent compelling evidence that the largest incumbent carriers are already using their existing spectrum licenses efficiently and their networks are still capacity-constrained, the

Department would normally expect the highest use value for new spectrum that is in the public interest to come from rivals to the leading firms that could effectively make use of additional spectrum to expand capacity, improve coverage, or introduce new services in an effort to challenge the dominant firms.”²³

- (48) This report does not address the extent to which mobile wireless service providers are capacity constrained. That question has been separately addressed by economists and industry analysts. For example, Allan Shampine submitted a declaration on behalf of Verizon in which he calculated the customers per MHz*POP of various wireless operators and concluded that Verizon and AT&T use their spectrum more intensively than other operators, including T-Mobile and Sprint.²⁴ And a recent market research report by Deutsche Bank labels Sprint the “new spectrum powerhouse” and emphasizes that Sprint has “more bandwidth available for LTE than all of its national competitors combined.”²⁵ Similarly, Macquarie Capital recently commented that Sprint and T-Mobile have a “strong spectrum and network capacity position” and that Verizon and AT&T “will need to purchase additional spectrum” within the next two years.²⁶
- (49) Additional economic evidence speaking to the issue can be found in a review of pricing plans offered by the four national providers. On the one hand, if a wireless carrier is relatively unconstrained in terms of its network capacity, one would expect that it would offer pricing plans that allow for customers to use large amounts of data or even offer plans with unlimited data usage. On the other hand, one would expect carriers that are more capacity constrained to offer plans that encourage customers to conserve on network capacity.
- (50) Statements by the FCC and industry analysts support the economic logic that wireless operators’ pricing plans can be expected to reflect their relative capacity constraints. For example, in the Fifteenth Annual CMRS Competition Report, the FCC stated: “In late 2009 [...] the chief executive of AT&T’s wireless operations hinted that the company would eventually shift from unlimited data pricing to charging subscribers based on the amount of data used in order to encourage high-usage customers to curb demand for network capacity and improve the operator’s ability to manage its network. Analysts have long anticipated the introduction of usage-based wireless data pricing, arguing that a departure from the unlimited data pricing model is only a matter of time. In June 2010, AT&T became the first national operator to move from unlimited data pricing to usage-based tiered data pricing for smartphones.”²⁷ In the Sixteenth CMRS Competition Report, the FCC confirmed

²³ DOJ ex parte at p.12.

²⁴ Declaration of Allan L. Shampine, In the Matter of Policies Regarding Mobile Spectrum Holdings, Docket No. 12-269 (Nov. 26, 2012), at 18-19, available at <http://apps.fcc.gov/ecfs/document/view?id=7022067975>.

²⁵ See Brett Feldman et al., Deutsche Bank Market Reports Research, *Sprint Nextel Corp. The New Spectrum Powerhouse; Restating Coverage at Buy* at 1, available at <http://apps.fcc.gov/ecfs/document/view?id=7520931274>.

²⁶ July 29, 2013 Macquarie Capital report, “US Telecom Services: Spectrum and network capacity vs. traffic demand for the Big 4 wireless carriers.”

²⁷ See In the Matter of Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993 Annual

that more wireless carriers facing capacity constraints are shifting to usage-based data plans: “the Fifteenth Report [...] had focused on the industry’s shift from unlimited data pricing to tiered, usage-based data pricing for smartphones. As discussed in the Fifteenth Report, this shift was a response to the effects of increased bandwidth consumption by smartphone users on network utilization and capacity constraints.” The report also stated that Sprint has an “unlimited data pricing [...] and T-Mobile reintroduced an unlimited smartphone data pricing option.”²⁸

- (51) Figure 9 compares the individual post-paid plans of Verizon, AT&T, T-Mobile, and Sprint. During the first half of 2013, Sprint and T-Mobile offered service plans to their customers that allow those customers to increase their data use in an unlimited way at zero incremental cost to those customers. Sprint offered an unlimited data plan at \$110 per month, and T-Mobile offered an unlimited data plan at \$90 per month during the first quarter and \$70 per month during the second quarter, for an average price of \$80 per month. This type of pricing is consistent with a lack of binding capacity constraints. If network capacity were a problem for T-Mobile and Sprint, I would have expected to see pricing plans that encourage customers to conserve on network usage. In fact, a recent T-Mobile advertisement portrays AT&T’s network as overcrowded but T-Mobile’s network as having ample capacity.²⁹ Similarly, Sprint recently announced that customers who choose the “New Unlimited, My Way Plan” starting at \$80 per month would receive the “Sprint Unlimited Guarantee,” an offering that allows the customers “to lock-in unlimited talk, text and data not for just the next two years, but for life.”³⁰

Figure 9 Comparison of individual 2013 (Jan-Jun) post-paid plans including unlimited anytime minutes and unlimited text messaging—monthly charge (\$) and corresponding included data usage (GigaBytes)

	Sprint	T-Mobile	Verizon	AT&T
Data usage	Unlimited	Unlimited	4GB	4GB
Average 2013 price (\$ per month)	110	80	110	110

Source: Verizon.

Report and Analysis of Competitive Market Conditions With Respect to Mobile Wireless, Including Commercial Mobile Services, WT Docket No. 10-133 (2011) (“Fifteenth CMRS Competition Report”), at ¶¶87-88.

²⁸ The FCC also reported that “[t]he same network management issues motivating the ongoing shift from unlimited data pricing to tiered smartphone data plans in the postpaid segment – namely, the impact of higher bandwidth consumption by smartphone users on network utilization and capacity constraints – are also beginning to induce changes in the pricing and service terms and conditions of high-end prepaid plans for users of smartphone data.” ¶167; see In the Matter of Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993 Annual Report and Analysis of Competitive Market Conditions With Respect to Mobile Wireless, Including Commercial Mobile Services, WT Docket No. 11-186, released March 21, 2013 (“Sixteenth CMRS Competition Report”).

²⁹ See, e.g., PhoneArena.com, “T-Mobile ad attacks AT&T for having slow pipes,” *available at* http://www.phonearena.com/news/T-Mobile-ad-attacks-AT-T-for-having-slow-pipes_id42743, site accessed July 4, 2013; T-Mobile “Pipes” Apple iPhone 5 Commercial, *available at* <http://www.youtube.com/watch?v=h2Scc6fGz9o>, site accessed July 4, 2013.

³⁰ See, e.g., “Sprint Launches Unlimited Guarantee and New Unlimited, My Way Plan,” *available at* http://newsroom.sprint.com/news-releases/sprint-launches-unlimited-guarantee-and-new-unlimited-my-way-plan.htm?view_id=2933, site accessed July 23, 2013.

- (52) In contrast, Verizon and AT&T have commonly offered service plans that cap the amount of data that is available to customers at zero incremental cost. Most recently, both Verizon and AT&T offered plans that allow for 4 GB of data usage at \$110 per month. Plans that limit the data usage that is available at no incremental cost are consistent with the kind of pricing that I would expect from a wireless carrier that is capacity constrained relative to carriers offering unlimited plans.
- (53) Therefore, the pricing behavior of the four national wireless operators is not consistent with the assertion that Verizon and AT&T are purchasing spectrum they do not need for their operations in order to ensure that their competitors remain capacity constrained.

IV. Verizon and AT&T are unlikely to have the incentive or ability to foreclose Sprint and T-Mobile in the Incentive Auction

- (54) In its submission, DOJ expresses concern that Verizon and AT&T will engage in a form of predatory bidding that will drive up the price of spectrum in the Incentive Auction to such an extent as to deny Sprint and T-Mobile the ability to acquire low-frequency spectrum in rural areas, which DOJ claims is needed to improve network coverage. But the DOJ paper includes no data or other evidence to support its concern, and DOJ subsequently clarified that it has not made any judgment about what the FCC will find when it undertakes the factual analysis needed to evaluate the concerns.³¹
- (55) Verizon and AT&T could have an incentive to purchase spectrum with the intent of withholding it from the market and thus decreasing supply in order to raise or maintain price levels only if smaller rivals are already constrained in terms of spectrum and Verizon and AT&T are not. However, the pricing plan evidence that I present in section III.C suggests that the opposite is true.
- (56) If margins are high and either Verizon or AT&T faces spectrum-capacity constraints in the coming years, then purchased spectrum will most likely be deployed in order to expand output at the high margins rather than withheld from the market. Furthermore, if smaller rivals are already unconstrained by their spectrum holdings, then withholding additional spectrum from them is unlikely to have any effect, while at the same time being costly to the larger wireless carriers. Therefore, if, as the evidence suggests, Verizon and AT&T are capacity-constrained relative to their smaller rivals, Verizon and AT&T would have no incentive to foreclose by purchasing spectrum to keep it out of the hands of their rivals.
- (57) Additionally, DOJ suggests that its concerns about low frequency spectrum may extend beyond rural markets if carriers require that spectrum to “offer[] coverage across a broad service area.” (DOJ *ex parte* at 14). But Sprint already has low frequency spectrum in the 800 MHz band, which it is using

³¹ Senate Judiciary Hearing, April 16, 2013, available at <http://www.judiciary.senate.gov/resources/webcasts/index.cfm>.

for its LTE deployment.³² And T-Mobile's senior management has made clear that any coverage constraints it may face can be remedied with the acquisition of a small amount of low-band spectrum: according to an analyst at Jefferies who recently met with T-Mobile's leadership, T-Mobile believes it only needs a 5x5 block of low frequency spectrum to improve its coverage "dramatically."³³ This suggests that Verizon and AT&T would have to buy up almost all of the low frequency spectrum at the 600 MHz auction to succeed in a foreclosure strategy targeting DOJ's potential non-rural concerns.

- (58) In the remainder of this section, I first address a much more direct remedy at the FCC's disposal that, unlike bidder participation restrictions, does not risk the success of the Incentive Auction. Then, I discuss some additional reasons why foreclosure by bidding up the price of spectrum in the Incentive Auction is unlikely to be an effective or profitable strategy for Verizon and AT&T: (1) Given the high costs associated with foreclosure and the uncertain benefit, both Verizon and AT&T would have an incentive to free ride on the efforts of the other to bid up the cost of spectrum. (2) Anonymous auction design would make the implementation of a foreclosure strategy difficult and costly. (3) The supply of spectrum is likely to increase as Verizon and AT&T bid up the price, increasing the cost of implementing a foreclosure strategy (4) The market does not appear to be sufficiently concentrated to make the foreclosure strategy profitable enough to justify the costs to Verizon and AT&T.

IV.A. As a policy tool to prevent foreclosure, build-out requirements have significant advantages over bidding restrictions

- (59) If, despite the evidence to the contrary, the FCC believes that foreclosure by purchasing spectrum with the intent of withholding it from use is likely, then a more direct and less risky remedy is available to the FCC.
- (60) The FCC can defeat a foreclosure strategy simply by imposing build-out requirements for licenses purchased at the Incentive Auction. DOJ notes in its ex parte submission that bidders may consider both use value and foreclosure value of spectrum when bidding. But bidders must also consider holding costs of any spectrum won, which offsets the perceived value. Holding costs of spectrum are increased by the extent to which the FCC requires that holders of spectrum pursue the build out of capacity in order to make use of acquired spectrum. Thus, the FCC has a tool at its disposal by which it can directly reduce the likelihood that firms will find it profitable to withhold spectrum from the market through a warehousing strategy.

³² See Sprint Q2 2013 Earnings Call (July 30, 013).

³³ August 28, 2013 Jefferies report, "T-Mobile USA". ("... T-Mobile believes that its coverage would improve dramatically with just a small (5x5) channel of low band spectrum.")

- (61) The imposition of a build-out requirement does not have to cause the significant risks and distortions that bidding restrictions do. Suppose that, as the evidence suggests, neither Verizon or AT&T (or anyone else) has any intention of purchasing spectrum in the Incentive Auction to withhold it from the market. Then a properly designed build-out requirement would only minimally impact bidding behavior, if at all. In such a case, however, bidding restrictions would unnecessarily put at risk the goals of the Incentive Auction and interfere with the efficient allocation of spectrum. Therefore, build-out requirements will tend to be a much more efficient means of deterring foreclosure than bidding restrictions.
- (62) In addition, because increases in the supply of spectrum reduce the profitability of a foreclosure strategy, the FCC can address foreclosure concerns by taking steps to accelerate the reallocation of spectrum, such as that currently assigned to the Federal Government, to use for commercial mobile wireless services.
- (63) Moreover, if DOJ is concerned about foreclosure in rural areas, it could examine the results of the auction and bring challenges if it uncovers anticompetitive conduct. For the reasons described in this report, I think it is unlikely that Verizon and AT&T would have an incentive to engage in foreclosure, but DOJ could easily determine whether AT&T and Verizon had purchased all or almost all of the relevant spectrum in the auction at prices significantly in excess of expectations, and then DOJ could investigate whether that was in pursuit of foreclosure. DOJ could use such a post-auction review to challenge foreclosure instead of a prophylactic rule restricting bidding by Verizon and AT&T.
- (64) Because the FCC could impose build-out requirements and the DOJ could examine bidding behavior post-auction in rural areas, policy tools exist for addressing foreclosure concerns that avoid the undesirable effects of bidding restrictions.

IV.B. Incentives to free ride imply that there is unlikely to be a unilateral incentive for significant foreclosure by either Verizon or AT&T

- (65) Free rider concerns suggest that a foreclosure strategy may be difficult for AT&T and Verizon to implement. DOJ's theory involves Verizon and AT&T both being willing to warehouse all or almost all the rural spectrum up for auction to prevent Sprint and T-Mobile from gaining access to that spectrum. That means that a significant portion of the foreclosure costs borne by Verizon or AT&T will benefit the other firm.
- (66) The effect of this will be to greatly reduce Verizon's and AT&T's unilateral incentives (if any) to foreclose well below the incentive that a single large firm would have. A single large firm would internalize all of the additional profits from the foreclosure strategy. When benefits are shared,

however, each firm sharing the benefits would prefer to free ride on the other's efforts, leading to significantly less foreclosure than would have occurred if the benefits were not shared.

IV.C. Anonymous auction design makes foreclosure less likely

- (67) The FCC can make auction design choices that reduce concerns related to foreclosure. In past auctions, the FCC has used anonymous bidding procedures in order to limit the scope for strategic bidding. By using anonymous bidding in the Incentive Auction, the FCC can prevent bidders from knowing the identity of rivals for a particular license, making a foreclosure strategy more difficult and costly to implement.
- (68) In the context of an auction with anonymous bidding, it would not be possible for Verizon or AT&T to know when one of them (as opposed to one of the firms supposedly a target of their foreclosure strategy) has won a license. The result is that Verizon and AT&T would not know when to stop bidding. Notably, as discussed in Section VI.C below, in the 700 MHz Auction, Verizon and AT&T competed head-to-head with one another for spectrum in various markets, even after all other participants had stopped bidding. In fact, that head-to-head competition between Verizon and AT&T contributed to more than \$4.2 billion in additional revenues that would not have been received if AT&T and Verizon had stopped bidding as soon as one of them was guaranteed to acquire the license. None of the parties asserting that there is foreclosure risk has put forth a theory explaining how foreclosure could take place in the context of anonymous bidding and direct competition between Verizon and AT&T.

IV.D. Uncertainty about the level and elasticity of supply in an incentive auction makes a foreclosure strategy difficult to implement

- (69) A foreclosure strategy is particularly difficult to implement in the context of an incentive auction because higher bids on the part of buyers result in greater quantity being made available from sellers.
- (70) In an incentive auction, unlike other auctions the FCC has run, there is significant uncertainty regarding the ultimate supply of spectrum to the market. The nature of the Incentive Auction involves broadcasters making decisions about the price at which they are willing to supply spectrum to the market. It will be difficult for participants to predict before the auction how much will be supplied at a given price level. A company seeking to implement a foreclosure strategy that involves bidding up the price of spectrum so as to purchase that spectrum in order to withhold it from the market already faces uncertainty over how high it will have to bid in order to keep spectrum away from rival bidders. An incentive auction introduces additional uncertainty associated with how much spectrum will have

to be purchased at inflated bids. This uncertainty makes planning and implementing this foreclosure strategy difficult and costly.

- (71) The extent to which higher prices stimulate sellers to offer more spectrum for sale is reflected in the elasticity of supply. If supply is highly elastic, then a small increase in price results in a large increase in the quantity of spectrum supplied. To analyze the effects of supply elasticity, auction theorists consider the set of equilibria of an auction, where an equilibrium is a specification of bidding strategies, one for each bidder, that are mutual best responses. These equilibria provide predictions on likely outcomes for the auction. The theory for one-sided auctions suggests that the elasticity of supply and uncertainty regarding that elasticity affects the set of equilibria in these auctions, with greater uncertainty and more elastic supply eliminating certain equilibria that may be undesirable from the perspective of the auction designer.³⁴ It seems likely that uncertainty regarding the elasticity of supply in the Incentive Auction would further inhibit attempts by bidders to coordinate on a foreclosure strategy. For example, if bidders are unsure about the elasticity of supply, they may be unsure about whether coordination on foreclosure strategies can be supported as an equilibrium, or if their beliefs about the elasticity of supply differ, they may disagree regarding foreclosure strategies.

IV.E. The market for wireless services is unlikely sufficiently concentrated to make foreclosure profitable

- (72) In all models of competition that I am aware of, the effects of foreclosing a rival diminish as the number of firms already effectively competing in the market increases. For example, a monopolist that is able to foreclose an entrant in order to remain a monopolist rather than sharing a duopoly profit will find that foreclosing that rival is significantly more profitable than foreclosing a rival that, had it been able to enter, would have become the third competitor rather than the second. Similarly, foreclosure of a fourth rival is significantly less profitable than foreclosing the third.
- (73) For example, consider a market consisting of symmetric firms competing by setting quantities facing inverse demand equal to $p = 100 - q$, where p is the market price and q is the total quantity supplied to the market. This is an example of a model of Cournot competition.³⁵ Assuming that firms produce at zero cost, the equilibrium price is equal to $100/(n + 1)$, where n is the number of symmetric firms in the market. Equilibrium profit of each firm is equal to $(100/(n + 1))^2$. The aggregate value to the remaining firms of foreclosing one potential entrant decreases as the number of firms in the market increases. Specifically, if there are two potential competitors but one is foreclosed, the value of

³⁴ See Paul Milgrom (2004), *Putting Auction Theory to Work*, Cambridge University Press, Chapter 7.2, showing that when bidders at a multi-unit auction face elastic supply rather than inelastic supply, some low-revenue equilibria may be eliminated.

³⁵ See, e.g., Jean Tirole (1989), *The Theory of Industrial Organization*, Cambridge, MA: MIT Press, Section 5.4.

foreclosure is approximately 1,389.³⁶ If there are three potential competitors but one is foreclosed, the joint value of foreclosing the third firm for the two other firms is approximately 972.³⁷ If there are four potential competitors but one is foreclosed, the joint value of foreclosing the fourth firm for the three other firms is 675.³⁸

- (74) The current market structure for mobile wireless services in the United States involves a significant number of national and regional competitors of various sizes and strengths. The potential foreclosure that is described by DOJ does not involve the complete foreclosure of a rival by a monopolist but rather is marginal in nature. It involves (theoretically) foreclosing rivals' access to a small subset of the available input when there are already many small, medium, and large-sized rivals and therefore the value of that foreclosure and its effect would likely be small.
- (75) In addition, the costs of a successful foreclosure strategy are likely to be large because it would require a firm to purchase licenses for large amounts of spectrum and then to fulfill any build-out requirements associated with those licenses.
- (76) In sum, in the Incentive Auction, bidders likely will not know whom they are bidding against, making a targeted foreclosure strategy difficult or impossible to implement. In addition, a firm will not know whether a higher bid will have the effect of increasing the total amount of spectrum available in the market. This uncertainty, together with the limited benefits and high costs of a foreclosure strategy, suggests that firms will not have the incentive to engage in such a strategy.

V. Effects of bidding restrictions in the economics literature

V.A. Papers on auction design suggest that bidding restrictions are likely to reduce revenue and efficiency

- (77) Economic theory supports the intuitive conclusion that a seller should be able to raise more money when running an auction that does not exclude any bidder than an auction that excludes even a single bidder. Bulow and Klemperer (1996) prove a theorem that shows that, when the auctioneer's goal is to raise the highest amount of money possible, "an auction with $N + 1$ bidders beats any standard mechanism for selling to N bidders."³⁹

³⁶ The profit of a monopolist is 2500, whereas the profit of a duopolist is approximately 1111, where $2500 - 1111 = 1389$.

³⁷ With three firms, each firm has profit 625, but with two each has profit 1111, and $2(1111) - 2(625) = 972$.

³⁸ With four firms, each firm has profit 400. Using the prior result, $3(625) - 3(400) = 675$.

³⁹ Jeremy Bulow and Paul Klemperer (1996), "Auctions Versus Negotiations," *The American Economic Review*, Vol. 86, No. 1, pp. 180-194.

- (78) The authors show that this conclusion requires only that the bidders are “serious,” that is, they value the object for sale more than the seller, and holds true under fairly general conditions. In particular, the conclusion that there is nothing as valuable to a seller as attracting one extra bona fide bidder to a competitive auction holds true both under “private values” conditions, “common value” conditions, and anything in-between. In a “private value” scenario, each bidder knows how much she values the object for sale; this information is private to herself and would not affect the values of other bidders if that information were revealed to them. In contrast, in a “common value” scenario, the value of the object for sale is the same for all bidders, but it is unknown at the time of the auction (e.g., the amount of oil that can be extracted after winning an oil lease auction).
- (79) This result suggests that a seller should generally focus on maximizing the number of bidders. In the authors’ own words: “A simple competitive auction with $N + 1$ bidders will yield a seller more expected revenue than she could expect to earn by fully exploiting her monopoly selling position against N bidders.”⁴⁰
- (80) Combining theoretical and empirical analysis, Brannman, Klein, and Weiss (1987) show that having more bidders results in higher winning bids both in theory and in the data in a range of different auction settings, including underwriters’ spreads on tax-exempt general obligation bonds and on tax-exempt revenue bonds, U.S. Department of Interior offshore oil lease auctions, and oral ascending and sealed-bid auctions of National Forest Service timber in the Pacific Northwest.⁴¹

V.B. Assertions that bidding restrictions might not suppress revenue are based on unrealistic hypothetical scenarios

- (81) In his March 12, 2013, declaration on behalf of T-Mobile,⁴² Prof. Jonathan B. Baker posits the following theoretical exception to the typical revenue result expected when bidding restrictions are imposed: “Given the non-trivial fixed costs of auction participation, a firm expecting to be outbid

⁴⁰ See also Vijay Krishna (2002), *Auction Theory*, New York: Academic Press. More nuanced effects are possible in models with participation costs and investments. For example, in Flavio M. Menezes and Paulo K. Monteiro (2000), “Auctions with endogenous participation,” *Review of Economic Design* 5, 71-89, the authors distinguish between the number of bidders who pay the participation costs required to *actually* participate in an auction and the number of bidders who could *potentially* participate in an auction. The auctioneer’s expected revenue always increases in the number of bidders who actually participate in an auction, but they show that an increase in the number of bidders who could potentially participate could in theory cause the auctioneer’s expected revenue to decrease, although they conclude that not much can be said in general about the likelihood of this effect. In Richard J. Gilbert and Paul Klemperer (2000), “An Equilibrium Theory of Rationing,” *RAND Journal of Economics* 31(1), 1-21, the authors consider a model in which the seller sets its pricing policy and then each of two buyers must make an initial sunk investment that determines probabilistically whether its value is positive or zero. In this case, the seller’s prices must provide incentives for investment and the seller may prefer to commit to sell to only one buyer in order to promote investment.

⁴¹ Lance Brannman, J. Douglass Klein and Leonard W. Weiss (1987), “The Price Effects of Increased Competition in Auction Markets,” *Review of Economics and Statistics* 69(1), pp. 24-32.

⁴² Jonathan B. Baker, “Spectrum Auction Rules That Foster Mobile Wireless Competition,” paper submitted on behalf of T-Mobile, *In the Matter of Policies Regarding Mobile Spectrum Holdings*, WT Docket No. 12-269.

could readily be deterred from participating in the auction in the first place. If auction participation is thin as a result of this dynamic, the large incumbent firms that are in principle willing to pay to obtain foreclosure benefits may enjoy these benefits without bidding up the auction price to a level that pays for those benefits fully, leaving the public with a less competitive wireless sector and the government with lower revenues than could be obtained.” Similarly, in their paper on behalf of Sprint, economists Dr. Stanley M. Besen, Dr. Serge X. Moresi, and Prof. Steven C. Salop state that: “*Economic theory* has shown that unrestricted auctions *can* discourage some potential bidders and lead to the result that auction revenues fall far short of expectations.”⁴³

- (82) However, both T-Mobile's and Sprint's economists limit themselves to hypothetical examples illustrating how the typical outcome—a reduction in revenue—might not occur (under their theories) if certain theoretical conditions are met. They present no evidence that the conditions that they claim might lead to a revenue-enhancing outcome are present in the context of the Incentive Auction or any other spectrum auction in the United States.
- (83) For example, neither Dr. Baker nor Sprint's economists provide evidence that in the Incentive Auction smaller bidders will face “non-trivial fixed costs” to participate, or that such costs would cause them to be discouraged from participating if larger bidders are permitted to participate without restrictions.
- (84) The data indicate that the hypothetical conditions posited by T-Mobile's and Sprint's economists do not appear to be present. For example, in the AWS auction, it was known that Verizon, AT&T, and T-Mobile would participate without restrictions, yet 168 qualified bidders registered for the auction and 104 bidders won licenses during the auction.⁴⁴ One of those bidders was T-Mobile, which won more licenses and spent more money than either Verizon or AT&T. Similarly, in the 700 MHz auction, there were 214 qualified bidders, of which 101 won licenses. Neither T-Mobile's nor Sprint's economists explain how the substantial number of active participants in those past actions is consistent with their apparent assumption that “non-trivial fixed costs” of auction participation may deter smaller bidders from participating in future U.S. spectrum license auctions.
- (85) Sprint's and T-Mobile's economists do not appear to assert that their clients are among the “smaller” firms that may be deterred from participating in auctions if there are not restrictions on Verizon and AT&T. Given those companies' substantial financial resources and their proven historical ability to acquire spectrum when they seek to acquire it, there does not appear to be a basis to conclude that the presence of “non-trivial fixed costs” for participating in the Incentive Auction would discourage their participation. Indeed, even if they provided factual support for their conjecture that *smaller* firms

⁴³ Stanley M. Besen, Serge X. Moresi, & Steven C. Salop, *Why Restricting Participation in Spectrum Auctions Can Increase Bidder Participation, Increase Auction Revenues, and Increase Competition in Wireless Markets*, Mar. 12, 2013 (filed with Sprint's reply comments in Docket No. 12-268), p. 3, emphasis added.

⁴⁴ See http://wireless.fcc.gov/auctions/default.htm?job=auction_summary&id=66.

may be deterred by the presence of unrestricted *larger* firms (and they do not), Sprint and T-Mobile do not explain why their own presence would not similarly deter smaller rivals from participating.

V.C. Empirical evidence from timber auctions further undermines the revenue theory advanced by Sprint and T-Mobile

- (86) U.S. Forest Service timber auctions are an apposite and instructive real-world test for Sprint’s and T-Mobile’s conjecture about likely outcomes when smaller bidders face non-trivial fixed costs to participate in auctions. When the U.S. Forest Service sells the rights to harvest timber in a given area (“tract”) by auction, it allows would-be participants to survey the tract to gather information about the value of the timber to be harvested. The evaluations of the idiosyncratic features of each tract are typically done through on-foot surveys of each tract by experienced experts known as “cruisers.”⁴⁵ These surveys represent a non-trivial fixed cost of auction participation for small loggers who may consider participating in the auction in competition with large mills.⁴⁶ The U.S. Forest Service sets a fraction of harvesting contracts aside for small firms, thus providing the FCC with what economists call a “natural experiment” about the effects of bidder participation restrictions in a non-trivial context — timber sales were about \$1.5 billion per year in the early 1980s (although now they are about 1/10 of that amount).⁴⁷
- (87) Athey, Coey, and Levin (2013) estimate that, far from increasing revenue, set-asides reduced revenue from U.S. Forest Service auctions by 5% between 1982 and 1989 (around that time, timber sales were slightly less than \$1 billion per year) and reduced auction efficiency by 17%.⁴⁸ Brannman and Froeb (2000) estimate that, between 1974 and 1989, eliminating the set-aside program would have increased

⁴⁵ As stated in Baldwin, Marshall, and Richard (1997) “Bidder Collusion at Forest Service Timber Sales” *Journal of Political Economy*, 105: 657-699 at page 666, “Certain other facts regarding Forest Service sales are relevant to our study. . . . Second, old-growth timber is highly heterogeneous. Bidders invest significant resources in assessing its value through ‘cruises.’ Cruises are analogous to geological reports for offshore oil tract sales.”

⁴⁶ Athey, Levin, and Seira (2011) “Comparing Open and Sealed-Bid Auctions: Evidence from Timber Auctions,” *Quarterly Journal of Economics*, 126: 207–257, state that “the costs of surveying a tract can run to several thousand dollars” and estimate the median survey cost to be about \$3,000 in the Northern forests and about \$5,000 in the California forests. The authors also report that the median expected profit from winning an auction is roughly \$45,000 gross of surveying costs. For smaller bidders who tend to win half or a quarter of the auctions that are won by a median sized bidder, expected profit would tend to be 50 to 25 percent of \$45,000 or \$22,500 to \$11,500. Therefore, survey costs for such small bidders would represent a relatively large percentage of the overall expected profit from bidding in an auction.

⁴⁷ See historical summary and graph of Forest Service cut and sold data, available at http://www.fs.fed.us/forestmanagement/documents/sold-harvest/documents/1905-2012_Natl_Summary_Graph.pdf.

⁴⁸ Susan Athey, Dominic Coey, and Jonathan Levin, (2013), “Set-Asides and Subsidies in Auctions,” *American Economic Journal: Microeconomic*, 5(1): 1–27. The authors find that set-asides did increase small firms’ participation, but argue that bidding subsidies targeted at small firms would have increased small firms’ profits and the U.S. Forest Service revenues with a much more limited “efficiency” cost in terms of reduced quantity harvested.

auction revenues by 15%. In that period, the U.S. Forest Service timber auction revenues were slightly more than \$1 billion per year.⁴⁹

- (88) Thus, set-asides failed to increase auction revenue and the amounts traded in timber auctions, even though a theoretical argument could be made for large bidders having an advantage over smaller ones in those auctions. It is thus unreasonable to expect that set-asides primarily benefitting large bidders, such as Sprint and T-Mobile, would increase auction revenue (and auction efficiency as well) in the Incentive Auction.

VI. Simulating the effects of bidding restrictions in past spectrum auctions suggests large negative effects on revenue

- (89) In this section, I describe my simulation analysis and results of the impact of bidding restrictions if they had been imposed on the FCC's AWS spectrum auction (Auction 66) and 700 MHz auction (Auction 73). These are two large, relatively recent auctions in which Verizon and AT&T participated. Sprint and T-Mobile participated in the AWS spectrum auction, making that auction of interest for examining how bidding restrictions on Verizon and AT&T might affect those firms. The 700 MHz auction involved low-frequency spectrum, similar to the Incentive Auction. Thus, these two auctions provide useful test cases for the effects of bidding restrictions.
- (90) I simulate the effects of a number of different bidding restrictions, all of which would have a significant effect on the licenses that Verizon and AT&T would be able to bid on in the Incentive Auction:
- a. outright exclusion of AT&T and Verizon from the auction;
 - b. a 33% cap on low-frequency (below 1 GHz) spectrum holdings, applied pre-auction by market, such that a carrier would be excluded from bidding at auction in any market where its pre-auction spectrum holdings exceed 1/3 of the low-frequency spectrum in that market;
 - c. a 33% cap on low-frequency spectrum holdings applied post-auction by market, assuming that both AT&T and Verizon purchase 20 MHz of spectrum at auction.⁵⁰

⁴⁹ Lance Brannman and Luke M. Froeb, (2000) "Mergers, Cartels, Set-Asides, and Bidding Preferences in Asymmetric Oral Auctions," *Review of Economics and Statistics*, 82(2): 283-290. These authors concur with the Athey, Coey and Levin (2013) conclusion that a policy of granting bidding preference to targeted bidders is superior to set-asides.

⁵⁰ One of the problems with Sprint's and T-Mobile's proposals is that it is not clear what amount of to-be-auctioned spectrum would be included in the denominator for purposes of determining a bidder's share of low-frequency spectrum. Given that the quantity of supply is unknown prior to the Incentive Auction, how a spectrum aggregation cap affects a participant's ability to bid in a particular market depends on how much additional spectrum is cleared in the

- (91) The range of restrictions that I model is designed generally to cover the types of restrictions being proposed that would limit participation by AT&T and Verizon in the Incentive Auction. Differences between past auctions and the Incentive Auction, such as different license sizes (both spectrally and geographically) and different amounts of auctioned spectrum, make it difficult to model precisely some of the specific proposals that have been presented. For example, I understand that Sprint and T-Mobile have proposed that if AT&T or Verizon would be completely excluded from bidding in a particular market under their proposed 1/3 cap on low-frequency spectrum holdings, a “safety valve” may be appropriate under which they could bid on a small amount of spectrum (e.g., 10 MHz or 1/6 of the to-be-auctioned spectrum). Although precise modeling of the effects of such a policy is challenging, based on my findings regarding the effects of restrictions that fall short of outright exclusion, it is clear that any measure that materially reduces the demand that AT&T and Verizon bring to the Incentive Auction risks a material reduction in auction revenue.

auction, which is an unknown variable in the context of the Incentive Auction. That constitutes a significant uncertainty regarding how the cap would be applied. In the post-auction share cap exclusion scenarios, I assume that a total of 70 MHz is reallocated in the Incentive Auction. In other words, I assume the denominator used to calculate the firm’s share includes the presently-available low-frequency spectrum plus 70 MHz of to-be-auctioned spectrum. That is consistent with T-Mobile’s proposal that the FCC adopt a band plan featuring 35x35 MHz of paired spectrum.

- (92) Currently, both Verizon’s and AT&T’s individual shares of low-frequency spectrum are at least 33% in many of the 172 Economic Areas (EAs) into which the United States was divided by the Bureau of Economic Analysis of the U.S. Department of Commerce at the time of the first FCC auctions.⁵¹ Any Incentive Auction participation rule that prevents a carrier from participating in the bidding if its pre-auction low-frequency spectrum holdings are above the 33% threshold would be equivalent to excluding AT&T and Verizon, as reported in Figure 10. The calculations are based on 134 MHz of available low-frequency spectrum.

Figure 10 The effect of spectrum aggregation caps on Verizon’s and AT&T’s ability to bid in the Incentive Auction

POPs in EAs* where carrier could not bid when exclusion condition is:	Verizon	AT&T	Excluded population as a % of total U.S. population	
			Verizon	AT&T
Pre-auction low-frequency* holdings ≥ 33%	267,527,458	229,194,228	85%	73%
Post-auction low-frequency holdings ≥ 33% under a total of 70 MHz being re-allocated and named carrier seeking two 5x5 licenses	171,723,755	221,109,342	55%	71%

* U.S. EAs only, that is, excluding Puerto Rico (EA #173), U.S. territories (EAs #174-175) and Gulf of Mexico EA (#176).
 Note: assumes Verizon’s current Lower 700 MHz block B holdings are assigned to AT&T and Grain, pursuant to transfer applications recently approved by the FCC.
 Source: Calculations based on current spectrum holdings data provided by Verizon.

- (93) Figure 10 also reports how extensive the restraint on Verizon and AT&T would be under apparently less stringent participation rules based on post-auction low-frequency holdings. For illustrative purposes, I assume that the Incentive Auction would reallocate 70 MHz of spectrum. I then report the population in EAs where Verizon or AT&T could not win 20 MHz of spectrum because that additional spectrum would bring them above the 33% threshold (that is, above 68 MHz).⁵² Figure 10 highlights how limits, seemingly less stringent than outright exclusion, would still have the effect of preventing Verizon from procuring spectrum to serve over half of the U.S. population.

⁵¹ In 2004 the Bureau of Economic Analysis redefined its EAs, increasing their number from 172 to 179. See <http://www.bea.gov/SCB/PDF/2004/11November/1104Econ-Areas.pdf>. For the purposes of the AWS and 700 MHz Auctions, there were 176 EAs (see the band plans in Appendix B).

⁵² If Verizon and AT&T theoretically sought to acquire only a single 5x5 license, the proposed cap would exclude Verizon from markets representing 50% of the population and AT&T would be excluded from markets representing 30%. Although historical purchasing patterns suggest that Verizon might not be interested in making a 5x5 MHz purchase, I simulated this scenario and found that it would have led to revenue reductions in both of the auctions. Even assuming that those smaller licenses would have substantial value by themselves (a questionable assumption given the fixed costs Verizon and AT&T would incur deploying spectrum in a new band class), my analysis indicates revenue reductions of up to 25% under the simulation methodology described below. That reduction likely understates the revenue effect because I did not attempt to account for the lower levels of demand (i.e., only a 5x5 license instead of the amount actually acquired in the past auction) that AT&T and Verizon would have brought to the auction under this assumption.

VI.A. Procedure

- (94) For each auction under consideration, I identify the following data:
1. The complete set of bid amounts and net bid amounts (the actual paid amount including the bidding credit) submitted by each participant in every round for each license offered in that auction.
 2. Information on whether particular bids were withdrawn or dropped and the tie-breaking random numbers associated with each bid.
 3. Information on whether any of the bidders raised their own bid even though they did not need to do so to remain the highest bidder and the provisional winner in a particular round.
- (95) To determine the ranking of bidders, I first look at the bidders' round-specific highest bids. If there are ties, those are resolved by using the tie-breaking random numbers assigned by the FCC.

(96) In my AWS spectrum auction and 700 MHz auction simulations, in order to simulate the effects of bidder participation restrictions, I assume that all bids in the auctions remain as they were submitted, but I remove the bids of AT&T and Verizon as appropriate for the particular restriction scenario. For example, consider the effect of the exclusion of Verizon in the bidding over a particular license. As demonstrated in Figure 11, Verizon wins license AW-REA001-F in round 16 and pays \$1,335 million (highlighted in yellow). The provisional winning bid for each round (shown in bold) is defined as the round-specific highest bid (as in round 9). If there are ties, I use the tie-breaking random numbers assigned by the FCC to determine the provisional winning bid (as in rounds 10 or 12). Now assume that Verizon is not permitted to bid. The second-highest bidder, in this case T-Mobile, wins and pays an amount that exceeds the bid submitted by the third-highest bidder or equals the bid of the third-highest bidder but has a higher tie-breaking random number. In this example, T-Mobile pays \$644 million (highlighted in green), a bid that exceeds Dolan’s \$537 million submitted in round 10. I refer to this as the “As bid” method. I make adjustments for reserve prices, the absence of other bidders, and ties.

Figure 11 AWS spectrum auction simulation example (license AW-REA001-F)

Round	Bidder	Actual Bids		"As Bid" simulation	
		Bid (\$ millions)	Random number	Bid (\$ millions)	Random number
9	Verizon	248	0.16		
	Denali	248	0.65	248	0.65
	Dolan	273	0.40	273	0.40
	SpectrumCo (Sprint)	447	0.87	447	0.87
	Wireless DBS LLC	248	0.56	248	0.56
10	Verizon	537	0.21		
	Dolan	537	0.32	537	0.32
12	Verizon	644	0.66		
	T-Mobile	644	0.15	644	0.15
13	T-Mobile	773	0.27	773	0.27
14	Verizon	927	0.12		
15	T-Mobile	1,113	0.74	1,113	0.74
16	Verizon	1,335	0.68		

Source: FCC documentation.

Note: The provisional winning bids for each round are in bold. The original win is highlighted in yellow and the simulated win is in green.

(97) As another example, if Verizon were the second-highest bidder and so determined the price paid by the winner, then, when excluding Verizon, I assume that the same bidder wins but pays only the bid amount that would have been just enough to outbid the third-highest bidder, again adjusting appropriately for reserve prices. For instance, as demonstrated in Figure 12, AT&T wins license WY-CMA167-B in round 26 and pays \$3.17 million (highlighted in yellow). If Verizon and AT&T are not permitted to bid, the second highest bidder, in this case MetroPCS, becomes a winner. MetroPCS pays \$1.66 million if I use the “As bid” method (highlighted in blue) because in round 21 MetroPCS has to overbid Verizon’s \$1.51 million submitted in round 20. But if Verizon and AT&T are unable to bid, MetroPCS only needs to overbid Alltel, which submitted \$0.96 million in round 12. Hence, it is enough to bid only \$1.15 million submitted in round 13 by AT&T (highlighted in green). I refer to this as the “Minimum required bid” method and use it in the analysis that follows. This method is preferable to the “As bid” approach because it uses a more accurate model of bidding behavior. In particular, bidders would rationally bid only as much as it is necessary to overbid the preceding highest bid.

Figure 12 700 MHz auction simulation example (license WY-CMA167-B)

Round	Bidder	Actual Bids		"As Bid" vs. "Minimum required bid" simulation	
		Bid (\$ millions)	Random number	Bid (\$ millions)	Random number
12	Alltel	0.96	0.51	0.96	0.51
	AT&T	0.96	0.09		
13	AT&T	1.15	0.73	1.15	0.73
	Verizon	1.15	0.59		
18	Verizon	1.28	0.07		
19	AT&T	1.38	0.53		
20	Verizon	1.51	0.88		
21	AT&T	1.66	0.81		
	MetroPCS	1.66	0.80	1.66	0.80
22	Verizon	1.88	0.66		
	MetroPCS	1.88	0.27	1.88	0.27
23	AT&T	2.15	0.04		
	MetroPCS	2.15	0.64	2.15	0.64
24	AT&T	2.47	0.58		
	Verizon	2.47	0.31		
25	Verizon	2.84	0.56		
26	AT&T	3.17	0.36		

Source: FCC documentation.

Note: The provisional winning bids for each round are shown in bold. MetroPCS wins and pays \$1.66 million under the “As Bid” simulation method (highlighted in blue) and only \$1.15 million under the “Minimum required bid” method (green).

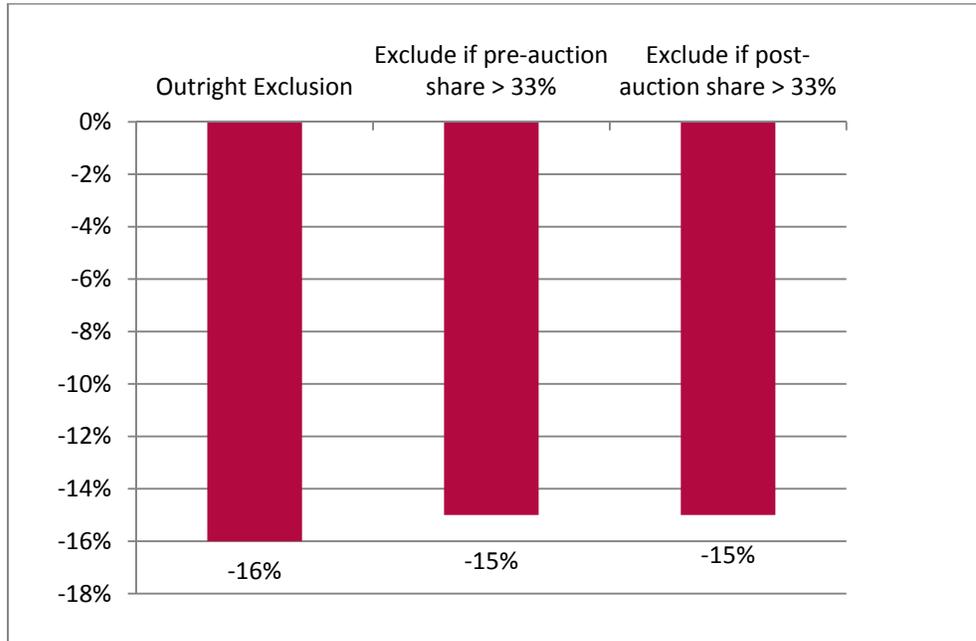
- (98) This methodology does not provide a perfect measure of the effects of excluding bidders, but it has the advantage of relying on the bids actually submitted at the auction to estimate effects. On the one hand, it will understate the revenue loss from excluding Verizon and AT&T in the following types of cases. Suppose bidder A would like to purchase one of two different licenses, which it views as substitutes, and that in the auction it wins one license and finishes as the second-highest bidder on the other, losing to Verizon. When I reevaluate the bids without Verizon, my methodology will predict that bidder A wins both licenses, when bidder A, who wants only one of the two licenses, might not have bid in such a way as to win both (even though prices are lower in the absence of Verizon). On the other hand, this methodology could theoretically overstate the revenue loss from excluding bidders if the absence of bidders such as Verizon and AT&T causes bidders to win licenses they would not have otherwise, and the acquisition of these licenses increases their value for other licenses due to complementarities, causing them to bid more aggressively on those other licenses. In addition, my methodology could theoretically overstate the revenue loss from exclusion if, for example, knowledge of the exclusion of certain bidders prior to the auction induces additional entry into the auction (in expectation of lower prices) thus increasing the competitiveness of the auction. However, I am not aware of any reason to expect that either the understatement or overstatement effect that is possible in my methodology would dominate.⁵³
- (99) This approach allows a detailed examination on a license-by-license basis of the potential impact of excluding specific bidders in specific markets that I believe is informative as to the likely effects of restrictions on bidder participation. In the absence of Verizon and AT&T, I expect that the bidding of other auction participants would have been largely similar (especially given the anonymous bidding format of 700 MHz Auction). Thus, I view the simulation results as informative as to the revenue reductions that one might expect to observe as a result of restrictions on the ability of Verizon and AT&T to participate.

VI.B. Results—Auction 66 - AWS spectrum auction

- (100) In this section I describe simulation results for the AWS auction. Appendix C describes the band plan for this auction.
- (101) As previously described, I considered three scenarios: outright exclusion of AT&T and Verizon, a pre-auction 33% share cap applied to AT&T and Verizon, and a post-auction 33% share cap assuming purchase of 20 MHz in the market applied to AT&T and Verizon. Simulating the effects of these exclusion scenarios results in a 15% to 16% reduction in revenue.

⁵³ As discussed in Section V.C above, the empirical evidence appears to undercut the suggestion by some parties that bidding restrictions on Verizon and AT&T might increase revenue by encouraging the participation of other bidders.

Figure 13 Summary of simulated revenue reductions in the AWS spectrum auction



Source: Calculations based on the FCC data and documentation.

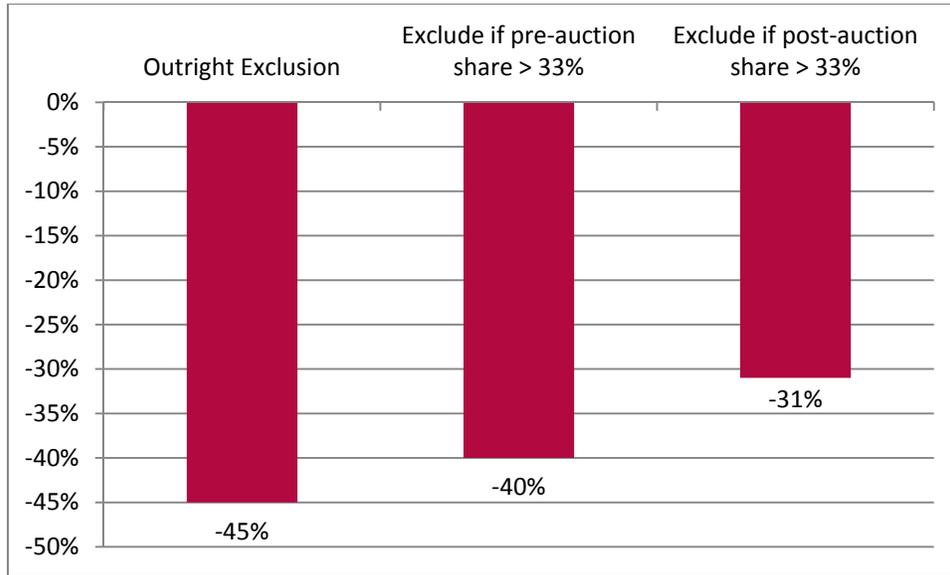
- (102) As Figure 13 reports for the three scenarios, the simulation estimates a revenue drop of between 15 and 16%. This implies that a pre- or post-auction share cap of 33% would have had almost the same effect as outright exclusion of Verizon and AT&T in the AWS auction.
- (103) I simulated the changes in the average price paid by top bidders as a result of the exclusion of Verizon and AT&T. T-Mobile enjoys the largest decrease in the average price per MHz*POP as a result of the exclusion – 18%. SpectrumCo (Sprint) enjoyed a 6% decrease in the average price it paid per MHz*POP.
- (104) Also, I calculated the results of a hypothetical version of the AWS auction in which all of the licenses were auctioned on a CMA basis. This provides a robustness check and offers a way to reduce effects related to the presence of small numbers of large licenses. The results, which are set forth in Appendix D, are similar to the results of the simulation of the actual auction.

VI.C. Results—Auction 73 - 700 MHz auction

- (105) I ran a similar simulation in the 700 MHz auction. This auction involved six categories of licenses referred to as Blocks A through F. Appendix C describes the band plan for this auction.

- (106) I simulate 700 MHz auction results under the same restriction scenarios as in the AWS spectrum auction simulations. Figure 14 summarizes my results.

Figure 14 Summary of simulated revenue reductions in the 700 MHz auction



Source: Calculations based on the FCC data and documentation.

- (107) In this auction, the revenue drop is even more dramatic. This is likely because of the particularly intense competition between Verizon and AT&T during that auction. In the 700 MHz Auction, AT&T and Verizon often competed against each other when bidding for 12 MHz of Block B CMA-level licenses. AT&T won 227 CMA-level licenses and paid \$6,637 million. Verizon won 77 CMA-level licenses and paid \$2,052 million.
- (108) If, hypothetically, AT&T and Verizon had not bid against each other in the auction,⁵⁴ my analysis of the auction data suggests that they would still have won all 304 CMA-level licenses, but would have paid only \$4,453 million instead of \$8,689 million. Thus, absent competition between AT&T and Verizon, 700 MHz auction total revenues would be \$14,722 million instead of \$18,958 million—22% lower. That result confirms that restrictions on Verizon and AT&T in the Incentive Auction would limit not just the participation of two significant buyers, but two significant buyers who have historically competed aggressively against one another, to the benefit of auction revenues.
- (109) The fact that head-to-head competition between Verizon and AT&T was robust also contradicts the suggestion that Verizon and AT&T were pursuing a foreclosure strategy: they collectively paid over

⁵⁴ There is no basis to expect, and no party appears to assert otherwise, that Verizon and AT&T would risk violating both the FCC’s bidder collusion rules and the antitrust laws by agreeing to not bid against one another.

four and a half billion dollars *more* for their spectrum than they would have had to if their goal had been to keep the spectrum out of the hands of competitors.

VII. Bidding restrictions in a simulated incentive auction

- (110) In addition to the revenue simulations described above, I also simulate the effects of restricting the participation in the Incentive Auction using a theoretical model of a two-sided auction.⁵⁵ Although the model does not capture all the complexity of the Incentive Auction, it does model the important interaction between supply and demand in a two-sided auction.
- (111) The interaction between supply and demand in a two-sided auction makes the problem of designing an incentive auction fundamentally different from the problem of designing a standard auction. The auctioneer does not know how much buyers are willing to pay nor how much sellers would require in order to be willing to sell. The auction mechanism must elicit this information from buyers and sellers, determine the quantities to be exchanged, and determine the amounts to be charged to buyers and paid to sellers, retaining the difference between the total amount received from buyers and the total amount paid to sellers as revenue to the auctioneer. Key ways in which a two-sided incentive auction differs from the standard one-sided auction include:⁵⁶
- 1) **Fully efficient two-sided mechanisms do not generate positive revenue.** In a two-sided market, in order to guarantee that goods are reallocated to their highest-value use—in the case at hand, making sure that this one-time opportunity to reallocate broadcast spectrum to higher-value wireless services does not go to waste—the market designer must be willing to take a loss in order to induce both sides of the market to reveal their true valuation of the object. In the Incentive Auction, as previously noted, Congress and the FCC seek to generate positive revenue, so a fully efficient mechanism is not an option.
 - 2) **The revenue-efficiency trade-off is steeper in an incentive auction.** In order to maximize revenue, the market designer must give up more in terms of the market’s ability to allocate licenses to the highest valuing users than in a standard auction. Parties involved need to

⁵⁵ Our model is based on the two-sided auction mechanism of Simon Loertscher and Claudio Mezzetti (2013), “A Dominant Strategy Double Auction with Multi-Unit Traders,” Working Paper, University of Melbourne, *available at* <http://www.simonloertscher.net/data/downloads/12120/LM-DoubAuc3.pdf>. This paper introduces a double auction mechanism in which buyers and sellers with multi-unit demand and supply have a dominant strategy to bid truthfully. The mechanism produces nonnegative revenue for the auctioneer and traders never regret participating (ex-post individual rationality is satisfied). In this Loertscher-Mezzetti double auction, the short side of the market trades at a single price, while the long side trades at prices determined by the well-known in the economics literature Vickrey-Clarke-Groves (VCG) mechanism (with a reserve price).

⁵⁶ The discussion in this paragraph is based on Simon Loertscher, Leslie M. Marx, and Tom Wilkening (2013), “A Long Way Coming: Designing Centralized Markets with Privately Informed Buyers and Sellers,” Working Paper, Duke University, *available at* <https://faculty.fuqua.duke.edu/~marx/bio/papers/incentiveauction.pdf>.

appreciate the negative efficiency consequences of demands for revenue on the Incentive Auction.

- 3) **The exclusion of strong buyers can have more severe consequences in an incentive auction.** An incentive auction can be more sensitive to the exclusion of a strong buyer than a standard auction. The effect is more pronounced the stronger is the strong buyer and less pronounced as the number of other buyers increases. In addition, in the Incentive Auction, a reduction in the amount of spectrum transacted has broader implications because it means that less spectrum will be reallocated from broadcast use to mobile wireless services and could potentially affect the repacking of the remaining broadcast licenses.

- (112) The simple two-sided auction model that I present in this section illustrates the trade-offs that the auctioneer faces and how the exclusion of bidders negatively affects the outcomes that the auctioneer may expect to realize. The auctioneer's two conflicting goals are auction revenue maximization on one hand and efficiency maximization on the other (i.e., the goal of facilitating all transactions for which the buyer values the good more than the seller).
- (113) If the auctioneer knows how much each seller and each buyer values the goods for sale, the auctioneer can achieve both goals by allowing all the trades where the buyer values the good more than the seller, and then requiring that each trading pair surrender the (positive) difference between their two values. However, in real world situations, the auctioneer will not know how much each seller and each buyer values the goods for sale, and therefore the auctioneer needs to design a mechanism to induce them to reveal such private information through their bids. In order to earn revenue, the auctioneer necessarily must reduce the number of trades below the efficient level. The distortion in the number of transactions may be large if the auctioneer seeks to maximize its revenue from the two-sided auction at the expense of efficiency.
- (114) In what follows, I show how market conditions, including the number of potential traders and their uncertain valuations from the auctioneer's point of view, give rise to a range of possible outcomes. These outcomes reflect the inherent trade-off in two-sided markets between auctioneer revenue and the efficiency of the auction. The outcome implemented by an auctioneer will depend on the auctioneer's preferences between the two conflicting goals. I show that the exclusion of bidders can substantially worsen the range of outcomes available to the auctioneer.

VII.A. Procedure

- (115) I calculate a relatively simple example to illustrate the trade-off between auctioneer revenue and efficiency and the effect of bidder exclusion. Given that this model is purely illustrative and not meant to be a quantitative prediction of the effects of exclusion, I do not attempt to calibrate it to

expected parameter values. In my set-up, 10 potential sellers each holding 1 unit of a homogenous good face 5 potential buyers, each interested in purchasing up to 4 units.

- (116) The auctioneer does not know how much the potential sellers value the units that they own. The auctioneer only knows that the value for any given seller is between \$0 and \$1 and that values between \$0 and \$1 are equally likely. Thus, I assume that the auctioneer expects that, on average, an individual seller values her unit at \$0.50, but the auctioneer knows that among the 10 sellers some sellers will randomly draw values much less than \$0.50 (and hence, relatively more willing to sell) and some sellers will randomly draw values much more than \$0.50 (hence, relatively less willing to sell). In particular, the auctioneer expects that, if it could see the valuations and line them up from lowest to highest, there would be a range of seller values spread between \$0 and \$1.⁵⁷
- (117) Similarly, the auctioneer does not know how much potential buyers are willing to pay for each of the 4 units each buyer is interested in. The auctioneer only knows that the value any given buyer places on a unit is between \$0 and \$1, but I assume that values greater than \$0.50 are relatively more likely so that the auctioneer expects that, on average, an individual buyer will value an individual unit at \$0.75.⁵⁸
- (118) To illustrate the trade-off between auction revenue and auction efficiency, I consider the outcomes the auctioneer can expect to achieve if it runs a two-sided auction mechanism based on the work of Loertscher and Mezzetti (2013). We can view the mechanism as a two-sided version of a multi-unit Vickrey auction with a reserve price,⁵⁹ which is a multi-unit extension of a second-price auction, in which bidders submit bids and the high bidder wins but pays only the amount of the second-highest bid. In Appendix E, I provide the technical details behind the illustrative simulations results presented in this section.

VII.B. Results

- (119) A two-sided auction can be designed to emphasize revenue or to emphasize efficiency through the selection of auction design parameters. In the model I use, a design that provides relatively high payments to sellers encourages them to supply more units, which tends to increase efficiency but reduce expected auctioneer revenue. A design that provides relatively low payments to sellers not only lowers the price paid to sellers but also reduces the number of units supplied, which increases

⁵⁷ I assume that sellers draw values randomly from the uniform distribution over the unit interval.

⁵⁸ More formally, I assumed that each buyer's value for a given unit is a random variable with support [0, 1] and cumulative distribution $F(x) = x^3$.

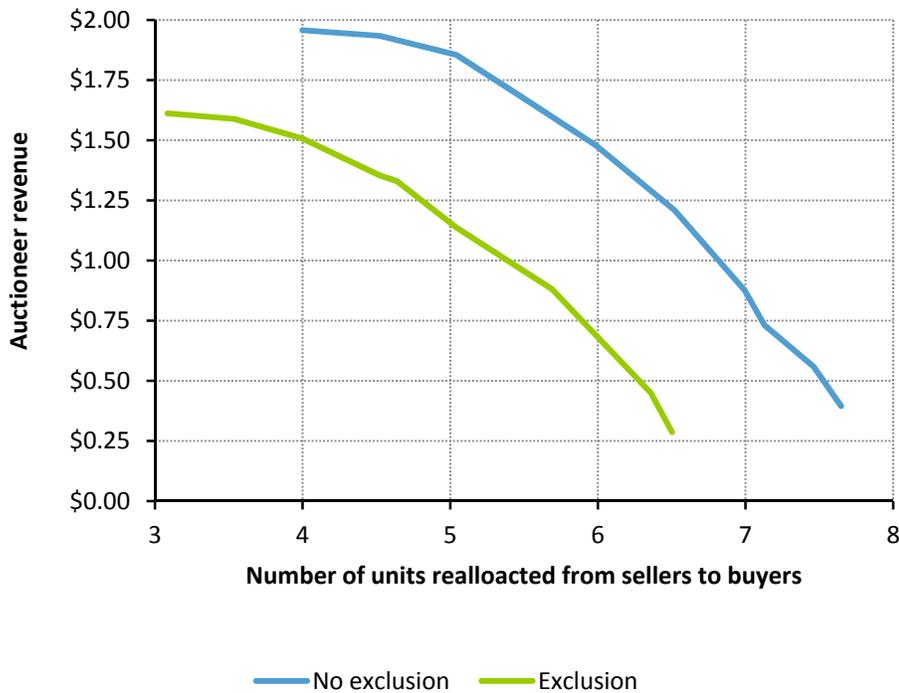
⁵⁹ See Vickrey, William (1961), "Counterspeculation, Auctions, and Competitive Sealed Tenders," *Journal of Finance*, 16: 8-37. This mechanism is sometimes referred to as a Vickrey-Clarke-Groves auction, as Clarke and Groves independently reached similar conclusions, see Clarke, E.H. (1971), "Multipart Pricing of Public Goods," *Public Choice*, XI, 17-33, Groves, Theodore (1973), "Incentives in Teams," *Econometrica*, 41: 617-31.

competition among the buyers and thus increases the average price buyers pay and the expected revenue to the auctioneer. Therefore, depending on the auction design, the auctioneer can emphasize revenue, efficiency, or balance the two.

- (120) That trade-off in my model is depicted in Figure 15. (See Appendix E for the details underlying this illustration.) Expected auctioneer revenue is on the vertical axis, and the expected number of units reallocated or traded is represented on the horizontal axis, where a larger number of units reallocated implies that the auction is more efficient. The curves in Figure 15 are downward sloping, which indicates that auction designs that produce greater expected revenue also produce a lower expected number of trades.

- (121) The blue line in Figure 15 shows the combinations of average revenue and numbers of trades that are feasible without exclusion. That is, without exclusion, if the auction is designed to maximize revenue, the auctioneer can expect to earn nearly \$2 with an average of 4 units changing hands. If instead the auction is designed to maximize efficiency, the auctioneer will expect to earn less than \$0.50 with an average of approximately 7.5 units changing hands. The blue curve between these two extremes represents all of the intermediate combinations of expected revenue and number of trades that are achievable depending on the auction design parameters chosen.⁶⁰ Similarly, the green curve depicts the combinations that are achievable if two of the five identical buyers are excluded.

Figure 15 Expected number of trades and auction revenues in a simple two-sided auction



Source: Calculations.

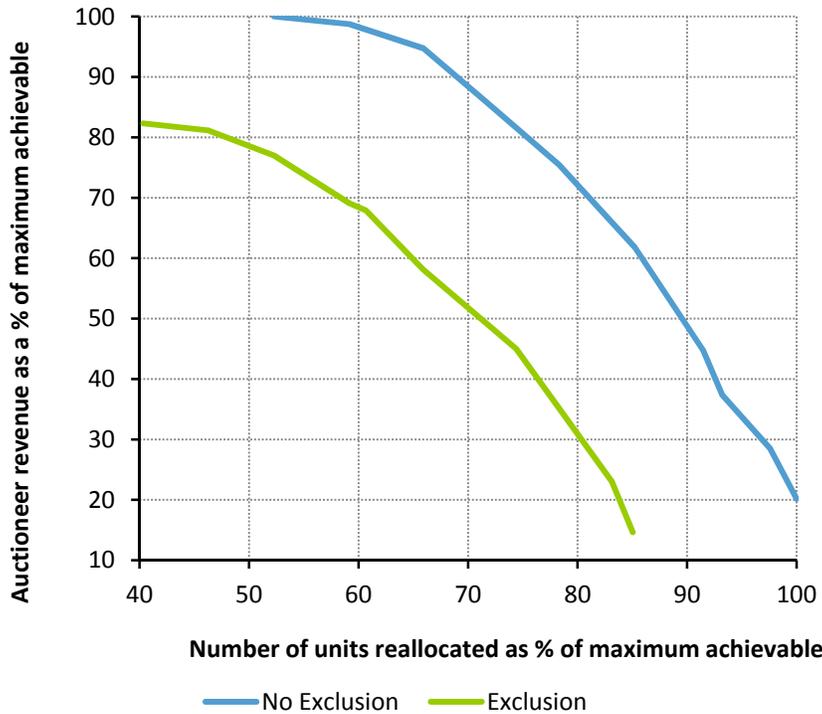
VII.B.1. Exclusion of bidders in a two-sided mechanism worsens the choices available to an auctioneer

- (122) In my illustrative model, the number of units traded are not calibrated to real-world values, so I redraw Figure 15 to express the *shift inward of the auction outcomes under exclusion* as a percentage

⁶⁰ These combinations of revenue and numbers of trades are achievable in an expected sense. The values of the buyers and sellers are random in the model. Therefore, for a given reserve price the number of trades and revenue will depend on the actual values drawn. The combinations of revenue and numbers of trades are the mean outcomes when values are redrawn and auction rerun many times.

of the maximum number of trades achievable under no exclusion—the point representing approximately 7.5 units in Figure 15 corresponds to 100 units in Figure 16 below. Similarly, because auction revenues in the model are not calibrated to real-world values, I redraw the figure so that approximately \$2.00 in auctioneer revenues in Figure 15 corresponds to 100 in Figure 16.

Figure 16 Impact of exclusion in a simple two-sided auction (max trades under no exclusion=100; max auctioneer revenue under no exclusion=100)



Source: Calculations.

- (123) As shown in Figure 16, exclusion reduces the maximum auctioneer revenue by just under 20%. (You can see this in the figure by noting that the maximum revenue value for the green line is just over 80.) Exclusion also reduces the efficiency-maximizing number of trades by approximately 15%. (The maximum number of trades for the green line is approximately 85.) An auctioneer aiming to find a compromise solution between these two conflicting targets stands to lose more than 20% on auction revenue and more than 15% on efficiency from exclusion. (The green line is more than 20% below the blue line, except close to the point of maximum revenue where it is slightly less than 20% below, and the green line is more than 15% to the left of the blue line.)
- (124) The set of revenue levels and numbers of transactions that can be achieved in a two-sided mechanism shifts down and to the left (towards lower revenue levels and fewer trades) when buyers are excluded. Bidding restrictions mean that the maximum possible revenue is reduced and the maximum number

of transactions that can be achieved is reduced. Furthermore, the feasible set of revenue levels and numbers of transactions is worsened from the perspective of the auctioneer.

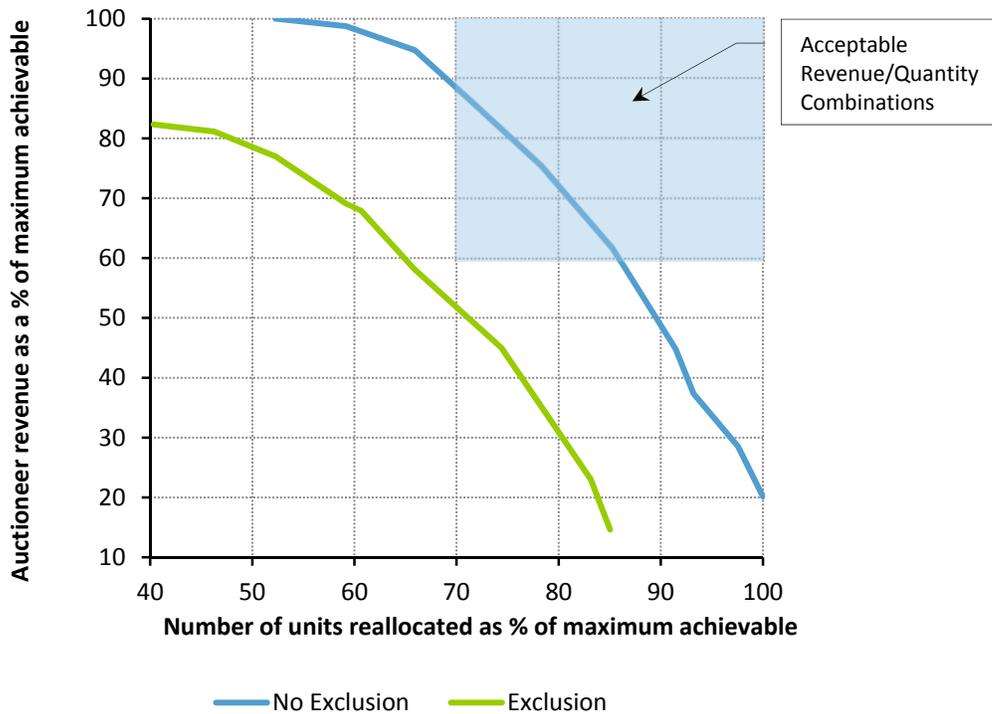
VII.B.2. Exclusion of bidders in a two-sided mechanism can cause revenue and transaction goals to be unattainable

- (125) As described above (see para. (20)), the Incentive Auction must raise a minimum level of revenue in order to succeed in reallocating licenses from broadcast TV to mobile wireless services. In addition, although not required by the authorizing legislation, it is clear that the Incentive Auction is being relied upon to fund the First Responder Network Authority (FirstNet) (see fn. 7).
- (126) Furthermore, the National Broadband Plan calls for the FCC to take steps to reallocate 120 MHz from the broadcast TV bands as part of the goal of making an additional 300 megahertz between 225 MHz and 3.7 GHz available for mobile use by 2015. As described in the National Broadband Plan, “Incentive auctions can be especially useful where fragmentation of spectrum licenses makes it difficult for private parties to aggregate spectrum in marketable quantities.”⁶¹

⁶¹ National Broadband Plan, Section 5.3, <http://www.broadband.gov/>.

- (127) If minimum thresholds of revenue and quantity transacted are required for the auction to succeed, then the elimination of two buyers can make achieving those thresholds impossible, causing the auction to fail. This case is illustrated in Figure 17, which assumes that auction success requires at least 70% of the maximum number of trades and 60% of the maximum revenue achievable under unrestricted competition. The blue-shaded box represents the range of outcomes that satisfy both requirements for auction success. As Figure 17 shows, exclusion results in failure to satisfy either requirement.

Figure 17 Exclusion may cause the illustrative two-sided auction to fail



Source: Calculations.

- (128) My understanding is that there are substantial technical challenges associated with configuring a band plan that makes a reasonable amount of paired spectrum available to wireless operators. Specifically, I understand that no party has presented a band plan designed to repurpose paired spectrum if the amount of cleared spectrum is less than 72 MHz in numerous markets because that is the minimum amount needed to configure a 25x25 MHz band plan. Given the potentially drastic result of an outcome where that minimum clearing threshold is not met, imposing restrictions that would materially suppress the quantity of spectrum repurposed would present a particularly acute risk of outright auction failure.

- (129) Therefore, bidding restrictions on buyers at the Incentive Auction have the potential to create an environment in which the goals for the Incentive Auction of revenue generation and spectrum reallocation cannot be achieved. In this sense, bidding restrictions can cause the Incentive Auction to fail.

VII.C. Proposals for a contingent auction would distort the auction process and potentially contribute to auction failure

- (130) T-Mobile recently proposed that the FCC apply strict bidding restrictions to Verizon and AT&T, but if certain revenue goals are not met, then the restrictions would be relaxed and the auction rerun, and so on, relaxing the restrictions repeatedly until revenue goals are met.⁶² That proposal would increase the complexity of an already complex Incentive Auction and would increase the risk of auction failure. Rerunning auctions can cause a number of problems from increased risk of coordinated bidding to distorted bidding incentives in an effort to game the system, which in complicated auctions can be difficult to predict and therefore avoid. In addition, even if such a mechanism theoretically allows the auction to achieve a revenue target, bidding restrictions will still decrease the amount of reallocated spectrum. Perhaps the most fundamental problem with the T-Mobile proposal is that it subverts the benefits of a two-sided auction as a means of determining the efficient allocation. The proposal would use a revenue target determined outside of the auction context to determine the amount of spectrum to be reallocated, but there is no way such a revenue target can reasonably be expected to achieve an efficient reallocation. If the auction were to meet the arbitrary set of revenue targets with restrictions on Verizon and AT&T, it is likely that the auction would have reallocated additional spectrum and/or raised more revenue had there been no restrictions.
- (131) It has been shown in the economics literature that contingent re-auctions are generally neither efficient nor optimal for the seller.⁶³ Strategic bidding in the 700 MHz auction as a result of the contingent re-auction format has been documented in the economics literature.⁶⁴ In order to avoid incentives for strategic bidding in the proposed auction format, detailed and potentially complex and restrictive activity rules would have to be put in place. However, such complicated restrictions would likely reduce the efficiency of the auction and would themselves create additional harmful effects.
- (132) One such harmful effect is illustrated by T-Mobile's attempt to address potential strategic bidding incentives by imposing an "activity rule" under which restrictions would be relaxed *only* in markets where the restricted bidders are actively bidding. That rule creates an exposure risk because it may

⁶² See <http://apps.fcc.gov/ecfs/document/view?id=7520934888>.

⁶³ Sandro Brusco, Giuseppe Lopomo, and Leslie M. Marx (2011), "The Economics of Contingent Re-Auctions," *American Economic Journal: Microeconomics* 3(2), 165-193.

⁶⁴ Sandro Brusco, Giuseppe Lopomo, and Leslie M. Marx (2009), "The 'Google Effect' in the FCC's 700 MHz Auction," *Information Economics and Policy* 21, 101-114.

require restricted bidders to bid on licenses that in and of themselves are of little value in order to retain and expand their eligibility to bid on the licenses they actually want. Take the example of a restricted bidder whose business plan calls for a 10x10 MHz license in a particular market and who places little value on a single 5x5 license. If the bidder only has “headroom” under the cap to bid on a single 5x5 MHz licenses, under T-Mobile’s proposal it would need to bid on a license that has little value by itself in order to have a chance of acquiring the license it does want. A firm in that position may choose not to bid on the smaller license because of the risk that it wins it without the ability also to acquire the complementary licenses that are needed for its business plan. That exposure problem is further complicated and exacerbated by the fact that, under the cap, firms will have different levels of headroom in different markets, which introduces an additional layer of complexity for firms interested in acquiring footprint-wide licenses of particular sizes.

- (133) T-Mobile’s proposal would also compromise the ability of restricted bidders to move their demand between geographic markets based on price feedback received during the auction. Consider a firm that is interested in acquiring a license in either Milwaukee or Kansas City, but not in both markets. Under a normal auction, that bidder could first seek to acquire a license in Kansas City and see how the bidding proceeds there, and then it may choose to shift its demand to Milwaukee if the Kansas City license becomes too expensive. Auction designs that support the ability of bidders to move demand between markets have been promoted by the FCC. But under the proposal, that strategy would be prohibited because the firm would lose its ability to bid in Milwaukee if it has not been actively bidding there starting in round one. The result is that a rational firm may not acquire *any* license even though it would have acquired a license in an unrestricted auction.
- (134) The exposure risks and strategic bidding incentives created by the proposal would not be limited to the restricted bidders. For example, the risk that the proposal leaves money on the table is heightened by the fact that non-restricted bidders would have the incentive to bid strategically to ensure that the revenue is target is met, but not exceeded, in order to avoid letting the restricted bidders have the opportunity to bid on more spectrum, which would increase overall bidding.
- (135) In sum, my prediction on the auction outcome under T-Mobile’s proposal is that Sprint and T-Mobile would raise their bids just enough to meet the revenue target and win the licenses at depressed prices. They and/or other winners at the auction would then have the ability to sell that spectrum on the secondary market to Verizon and AT&T at higher prices.

VIII. Conclusion

- (136) I have analyzed proposals to restrict the participation of Verizon and AT&T in the Incentive Auction in order to prevent the anticompetitive foreclosure of smaller rivals. The evidence does not support assertions that anticompetitive foreclosure is likely. (1) I have reviewed the outcomes of previous

auctions and find no evidence of foreclosure. (2) The evidence from secondary market transactions and previous auctions suggests that Sprint and T-Mobile failed to take advantage of numerous opportunities to purchase low-frequency spectrum. (3) A review of the pricing plans offered by Verizon, AT&T, Sprint, and T-Mobile is consistent with the conclusion that the networks of Verizon and AT&T are capacity constrained relative to Sprint and T-Mobile, implying that little would be gained from foreclosing Sprint and T-Mobile. (4) As both Verizon and AT&T would supposedly benefit from foreclosure of Sprint and T-Mobile, incentives to free ride on the other's efforts would further reduce any gains from foreclosure. (5) Successful foreclosure is complicated and made more costly by the fact that, in the Incentive Auction, an increase in bid amounts to deny Sprint and T-Mobile spectrum will tend to increase the amount of spectrum supplied to the market. (6) Finally, the market for wireless services does not appear to be sufficiently concentrated to make foreclosure profitable.

- (137) While not addressing a real problem, proposals to restrict the bidding of Verizon and AT&T conflict with the goals of the Incentive Auction: reallocation of spectrum to higher valued uses and revenue generation. In order to assess the impact of bidding restrictions, I have simulated their impact on Auction 66 (AWS) and Auction 73 (700 MHz) and found that restrictions would have significantly reduced the revenue generated in those auctions. In addition, I have simulated the exclusion of two bidders in an illustrative example of a two-sided market similar in structure to the Incentive Auction. The results illustrate the trade-off faced by an auctioneer in a two-sided setting between revenue generation and efficiency. Excluding bidders reduces both the amount of spectrum reallocated and the potential revenue generated.
- (138) The Incentive Auction represents a unique opportunity to reallocate underutilized spectrum to higher valued uses. It would be particularly unwise to artificially reduce demand in the Incentive Auction through restrictions on the bidding of Verizon and AT&T. Bidding restrictions conflict with the goals of the Incentive Auction by reducing both the amount of spectrum reallocated and the revenue potential of the auction. Such restrictions risk a complete failure of the auction by making the achievement of minimum revenue and spectrum reallocation thresholds impossible to achieve. Despite the evidence I have presented, if the FCC believes that foreclosure by Verizon and AT&T of smaller rivals is a real problem, I urge the FCC to consider other less distortionary policies to address the potential problem, such as build-out requirements and anonymous bidding. Complicated bidding procedures and bidding restrictions on top of an already complicated two-sided auction put at risk the goals of the Incentive Auction. I find such proposals both unnecessary and counterproductive.

Appendix A. Curriculum vitae of Leslie M. Marx, PhD

A.1. Education

- PhD, Economics, Northwestern University
- MA, Economics, Northwestern University
- BS, Mathematics, Duke University

A.2. Professional experience

- Fuqua School of Business, Duke University, Robert A. Bandeen Professor of Economics, 2013–present
- Fuqua School of Business, Duke University, William and Sue Gross Research Fellow and Professor of Economics, 2012–2013
- Fuqua School of Business and Department of Economics, Duke University, Professor of Economics, 2008–2013
- Associate Professor of Economics, Fuqua School of Business, Duke University, 2002–2008
- Chief Economist, U.S. Federal Communications Commission, August 2005–August 2006
- Associate Professor of Economics and Management, W.E. Simon Graduate School of Business Administration, University of Rochester, 2000–2002
- Visiting Associate in Economics, California Institute of Technology, January 2000–June 2000
- Associate Professor of Economics and Management, W.E. Simon Graduate School of Business Administration, University of Rochester, 1999–2000
- Assistant Professor of Economics and Management, W.E. Simon Graduate School of Business Administration, University of Rochester, 1994–1999

A.3. Teaching

- MBA: Managerial Decision Analysis, Managerial Game Theory, Environmental Economics
- Executive MBA: Managerial Economics, Managerial Decision Analysis, Managerial Game Theory
- PhD: Game Theory, Industrial Organization

A.4. Publications

- “Tacit Collusion in Oligopoly” (with Edward Green and Robert C. Marshall). In *Oxford Handbook of International Antitrust Economics*, eds. Roger D. Blair and D. Daniel Sokol. Oxford University Press, forthcoming.
- “Economics and the Efficient Allocation of Spectrum Licenses” (with Simon Loertscher). In *Mechanisms and Games for Dynamic Spectrum Access*, eds. Tansu Alpcan, Holger Boche, Michael L. Honig, and H. Vincent Poor. Cambridge University Press, forthcoming.
- “The Economics of Auctions and Bidder Collusion” (with Robert C. Marshall and Michael J. Meurer). In *Game Theory and Business Applications*, 2nd ed., eds. Kalyan Chatterjee and William F. Samuelson. New York: Kluwer Academic Publishers, forthcoming.
- *The Economics of Collusion: Cartels and Bidding Rings* (with Robert C. Marshall). Cambridge: MIT Press, 2012.
- “Plus Factors and Agreement in Antitrust Law” (with William E. Kovacic, Robert C. Marshall, and Halbert L. White). *Michigan Law Review* 110, no. 3 (2011): 393–436. Winner of the Tenth Annual Jerry S. Cohen Memorial Fund Writing Award given for the best antitrust writing during the prior year.
- “Bidder Collusion at First-Price Auctions” (with Giuseppe Lopomo and Peng Sun). *Review of Economic Design* 15, no. 3 (2011): 177–211.
- “Carbon Allowance Auction Design: An Assessment of Options for the U.S.” (with Giuseppe Lopomo, David McAdams, and Brian Murray). *Review of Environmental Economics and Policy* 5, no. 1 (2011): 25–43.
- “Coordinated Effects in the 2010 Horizontal Merger Guidelines” (with Wayne-Roy Gayle, Robert C. Marshall, and Jean-Francois Richard). *Review of Industrial Organization* 39, no. 1 (2011): 39–56.
- “The Economics of Contingent Re-Auctions” (with Sandro Brusco and Giuseppe Lopomo). *American Economic Journal: Microeconomics* 3, no. 2 (2011): 165–93.
- “Break-Up Fees and Bargaining Power in Sequential Contracting” (with Greg Shaffer). *International Journal of Industrial Organization* 28, 451–463 (2010).
- “Slotting Allowances and Scarce Shelf Space” (with Greg Shaffer). *Journal of Economics & Management Strategy* 19, no. 3 (2010): 575–603.
- “Cartels as Two-Stage Mechanisms: Implications for the Analysis of Dominant-Firm Conduct” (with Randall D. Heeb, William E. Kovacic, and Robert C. Marshall). *Chicago Journal of International Law* 10, no. 1 (2009): 213–31.

- “Individual Accountability in Teams” (with Francesco Squintani). *Journal of Economic Behavior & Organization* 72, no. 1 (2009): 260–73.
- “Quantitative Analysis of Coordinated Effects” (with William E. Kovacic, Robert C. Marshall, and Steven P. Schulenberg). *Antitrust Law Journal* 76, no. 2 (2009): 397–430.
- “The ‘Google Effect’ in the FCC’s 700 MHz Auction” (with Sandro Brusco and Giuseppe Lopomo). *Information Economics and Policy* 21 (2009): 101–14.
- “The Vulnerability of Auctions to Bidder Collusion” (with Robert C. Marshall). *Quarterly Journal of Economics* 124, no. 2 (2009): 883–910.
- “Cartel Price Announcements: The Vitamins Industry” (with Robert C. Marshall and Matthew E. Raiff). *International Journal of Industrial Organization* 26 (2008): 762–802. Awarded the 2009 Paul Geroski Best Article Prize for one of the best two articles published in the *International Journal of Industrial Organization* in 2008.
- “Bidder Collusion” (with Robert C. Marshall). *Journal of Economic Theory* 133 (2007): 374–402.
- “Coordinated Effects in Merger Review: Quantifying the Payoffs from Collusion” (with William E. Kovacic, Robert C. Marshall, and Steven P. Schulenberg). In *Annual Proceedings of the Fordham Competition Law Institute: International Antitrust Law & Policy*, ed. Barry E. Hawk, 271–85 (Huntington, NY: Juris Publishing, Inc., 2007).
- “Exploring Relations Between Decision Analysis and Game Theory” (with Jules van Binsbergen). *Decision Analysis* 4 (2007): 32–40.
- “Lessons for Competition Policy from the Vitamins Cartel” (with William E. Kovacic, Robert C. Marshall, and Matthew E. Raiff). In *The Political Economy of Antitrust*, vol. 282, eds. Vivek Ghosal and Johan Stennek, 149–176 (New York: Elsevier, 2007).
- “Rent Shifting and the Order of Negotiations” (with Greg Shaffer). *International Journal of Industrial Organization* 25 (2007): 1109–25.
- “Upfront Payments and Exclusion in Downstream Markets” (with Greg Shaffer). *RAND Journal of Economics* 38 (2007): 823–43.
- “Bidding Rings and the Design of Anti-Collusion Measures for Auctions and Procurements” (with William E. Kovacic, Robert C. Marshall, and Matthew E. Raiff). In *Handbook of Procurement*, eds. Nicola Dimitri, Gustavo Piga, and Giancarlo Spagnolo, 381–411 (Cambridge: Cambridge University Press, 2006).
- “Economics at the Federal Communications Commission.” *Review of Industrial Organization* 29 (2006): 349–68.

- “Inefficiency of Collusion at English Auctions” (with Giuseppe Lopomo and Robert C. Marshall). *Contributions in Theoretical Economics* 5, no. 1 (2005): article 4, <http://www.bepress.com/bejte/contributions/vol5/iss1/art4>.
- “Opportunism and Menus of Two-Part Tariffs” (with Greg Shaffer). *International Journal of Industrial Organization* 22 (2004): 1399–1414.
- “Opportunism in Multilateral Vertical Contracting: Nondiscrimination, Exclusivity, and Uniformity: Comment” (with Greg Shaffer). *American Economic Review* 94 (2004): 796–801.
- “The Joint Determination of Leverage and Maturity” (with Michael J. Barclay and Clifford W. Smith, Jr.). *Journal of Corporate Finance* 9 (2003): 149–67. Winner of Outstanding Paper in Corporate Finance at the 1997 Southern Finance Association Meetings.
- “Adverse Specialization” (with Glenn M. MacDonald). *Journal of Political Economy* 109 (2001): 864–99.
- “Insurer Ownership Structure and Executive Compensation as Complements” (with David Mayers and Clifford W. Smith, Jr.). *Journal of Risk and Insurance* 68 (2001): 449–63. Winner of Outstanding Paper in Financial Services at the 1998 Southern Finance Association Meetings.
- “Dynamic Voluntary Contribution to a Public Project” (with Steven A. Matthews). *Review of Economic Studies* 67 (2000): 327–58.
- “Adaptive Learning and Iterated Weak Dominance.” *Games and Economic Behavior* 26 (1999): 253–78.
- “Odd-Eighth Avoidance as a Defense Against SOES Bandits” (with Eugene Kandel). *Journal of Financial Economics* 51 (1999): 85–102.
- “Payments for Order Flow on Nasdaq” (with Eugene Kandel). *Journal of Finance* 54 (1999): 35–66.
- “Predatory Accommodation: Below-Cost Pricing Without Exclusion in Intermediate Goods Markets” (with Greg Shaffer). *RAND Journal of Economics* 30 (1999): 22–43.
- “Process Variation as a Determinant of Bank Performance: Evidence from the Retail Banking Study” (with Frances Frei, Ravi Kalakota, and Andrew Leone). *Management Science* 45 (1999): 1210–20.
- “Efficient Venture Capital Financing Combining Debt and Equity.” *Review of Economic Design* 3 (1998): 371–87; Winner of the Koç University Prize for the Best Paper of the Year in Review of Economic Design.
- “The Effects of Transaction Costs on Stock Prices and Trading Volume” (with Michael J. Barclay and Eugene Kandel). *Journal of Financial Intermediation* 7 (1998): 130–50.

- “Cost Effective Use of Muscle Relaxants: A Decision Analysis” (with Jeffrey S. Rubenstein, Wendy Colin, Darryl Jackson, Craig Lockwood, and Janice Molloy). *Pediatrics* 100 (1997): 451–52.
- “Nasdaq Market Structure and Spread Patterns” (with Eugene Kandel). *Journal of Financial Economics* 45 (1997): 35–60.
- “Order Independence for Iterated Weak Dominance” (with Jeroen M. Swinkels). *Games and Economic Behavior* 18 (1997): 219–45. “Corrigendum.” *GEB* 31 (2000): 324–29.

A.5. Working papers

- “Antitrust Leniency with Multi-Product Colluders” (with Robert C. Marshall and Claudio Mezzetti), 2013.
- “A Long Way Coming: Designing Centralized Markets with Privately Informed Buyers and Sellers” (with Simon Loertscher and Tom Wilkening), 2013.
- “Monopolization Conduct by Cartels” (with Robert C. Marshall and Lily Samkharadze), 2013.
- “Buyer Resistance for Cartel versus Merger” (with Vikram Kumar, Robert C. Marshall, and Lily Samkharadze), 2013.
- “Buyer Power, Exclusion, and Inefficient Trade” (with Greg Shaffer), 2009.
- “Opportunism and Nondiscrimination Clauses” (with Greg Shaffer), 2002.

A.6. Grants

- National Science Foundation Grant #SES-0849349, Applied Mechanism Design, 2009–2011
- National Science Foundation Grant #SES-0001903, “Economic Analysis of Sequential Vertical Contracting Environments,” 2000–2001
- Emerging Scholar Program Grant from the American Compensation Association, “Compensation and Control in Entrepreneurial Ventures,” 1997

A.7. Selected honors and awards

- Honored as an FCC Woman Leader by The Minority Media and Telecommunications Council, April 2013
- Honored as one of the *Global Competition Review* Top 100 Women in Antitrust, March 2013
- Named *Financial Times* Business School Professor of the Week, July 2012

- Awarded the 2012 Tenth Annual Jerry S. Cohen Memorial Fund Writing Award, given to the best antitrust writing during the prior year (Awarded for “Plus Factors and Agreement in Antitrust Law,” published in the *Michigan Law Review*)
- Awarded the 2009 Paul Geroski Best Article Prize for one of the best two articles published in the *International Journal of Industrial Organization* in 2008
- Simon School Teaching Honor Roll, 1999, 2001
- Koç University Prize for the Best Paper of the Year in Review of Economic Design, 1998
- Outstanding Paper in Financial Services at the Southern Finance Association Meetings, 1998
- Outstanding Paper in Corporate Finance at the Southern Finance Association Meetings, 1997
- Alfred P. Sloan Doctoral Dissertation Fellowship, 1993–1994
- National Science Foundation Graduate Fellowship, 1989–1992

A.8. Professional activities

- Council Member of Game Theory Society, 2013–present
- Editorial Board of *International Journal of Game Theory*, 12/2009-present
- Editorial Board of *Journal of Economic Literature*, 2010–2012
- Advisory Editor for *Games and Economic Behavior*, 2010–2012
- Editorial Board of *American Economic Journal: Microeconomics*, 2007–present
- Academic Affiliate of the Center for the Study of Auctions, Procurements and Competition Policy at Penn State University, 2007–present
- Associate Editor, *International Economic Review*, 2002–2005

Appendix B. Secondary market transactions, all bands

Figure 18 Number of transactions, all bands, January 2007–May 2013 (whole and partial licenses)

Counts of trades		Buyer					Total
		Verizon	ATT	T-Mobile	Sprint	Other	
Seller	Verizon		162	63	12	108	345
	ATT	15		85	8	29	137
	T-Mobile	127	36		28	43	234
	Sprint	15	16	17		28	76
	Other	1,010	1,350	121	33	1,847	4,361
	Total	1,167	1,564	286	81	2,055	5,153
	<i>buy/sell ratio</i>	<i>3.38</i>	<i>11.42</i>	<i>1.22</i>	<i>1.07</i>	<i>0.47</i>	

Source: Calculations based on FCC data and documentation.

Appendix C. Band plans for spectrum auctioned in the AWS and 700 MHz auctions

- (139) The figures in this appendix provide background information on the band plans used in the AWS and 700 MHz Auctions.

Figure 19 Auction 66 (AWS-1) band plan, reserve price, and minimum opening bids

Block	Frequencies	Pairing	Bandwidth	Area	Licenses	Total of Minimum Opening Bid Amounts
A	1710-1720 and 2110-2120 MHz	2 x 10 MHz	20 MHz	CMA	734	\$259,332,500
B	1720-1730 and 2120-2130 MHz	2 x 10 MHz	20 MHz	EA	176	\$259,342,000
C	1730-1735 and 2130-2135 MHz	2 x 5 MHz	10 MHz	EA	176	\$129,678,000
D	1735-1740 and 2135-2140 MHz	2 x 5 MHz	10 MHz	REAG	12	\$129,672,000
E	1740-1745 and 2140-2145 MHz	2 x 5 MHz	10 MHz	REAG	12	\$129,672,000
F	1745-1755 and 2145-2155 MHz	2 x 10 MHz	20 MHz	REAG	12	\$259,341,000
Totals					1,122	\$1,167,037,500

Source: FCC documentation.

Note: As for the reserve price, the FCC ruled as follows: “the winning bids (net of bidding credits) in the auction must total at least approximately \$2.06 billion in order for the Commission to conclude the auction and award the licenses.” (FCC 06-47, April 12, 2006)

Figure 20 Auction 73 (700 MHz) band plan, reserve prices, and winning bids

Block	Frequencies	Pairing	Bandwidth	Area	Licenses	Reserve Price (\$ millions)	Actual Net Winning Bids (\$ millions)	Net Bids with outright exclusion (\$ millions)
A	698-704, 728-734	2 x 6 MHz	12 MHz	EA	176	1,807	3,876	2,279
B	704-710, 734-740	2 x 6 MHz	12 MHz	CMA	734	1,374	9,068	2,704
C	746-757, 776-787	2 x 11 MHz	22 MHz	REAG	12	4,638	4,747	4,717
D	758-763, 788-793	2 x 5 MHz	10 MHz	Nationwide	1	1,330	Unsold	Unsold
E	722-728	unpaired	6 MHz	EA	176	904	1,267	1,241
Total			62 MHz		1,099	10,053	18,958	10,942

Source: FCC documentation.

Appendix D. Results assuming CMA-only licenses

- (140) In Auction 66, AWS licenses were defined over 734 small Cellular Market Areas (CMA), over 176 larger Economic Areas (EA), and over 12 large Regional Economic Area Groups (REAG). Under the 33% share exclusion rule, if the weighted average MHz market share of low-band spectrum for a large REAG were below 33%, AT&T and Verizon would be allowed to bid for such a license. However, if the proposed Incentive Auction is conducted at the CMA level, AT&T and Verizon would be excluded from many CMA markets within the REAG. Alternatively, AT&T or Verizon could be excluded from a particular REAG as a result of the 33% share exclusion rule, but would have been allowed to bid in many of the CMA markets within the REAG. Therefore, basing exclusion on shares in larger geographic regions may distort the degree of exclusion from the 33% share exclusion rule. As a robustness check, we rescale the AWS spectrum auction so that all licenses are over a CMA. I find that my results are generally consistent with my simulation results without this rescaling.
- (141) In order to account for the circumstances described above, I use the Auction 66 results to create a new set of auction results. For each EA and REAG license, I create a set of artificial licenses associated with each CMA within an EA or REAG. In order to simulate bidding on these artificial CMAs, I assume that the bidders on the artificial CMA licenses are the same as the bidders for the associated EA or REAG, and I allocate the bids on the EA or REAG to the artificial CMA licenses proportionally to the population of the CMA. By creating these artificial CMA licenses, I create an auction in which each CMA has 6 licenses associated with it, one from Block A, which was the original CMA license, and others from Blocks B, C, D, E, and F, represented by the artificial licenses with scaled-down bids.⁶⁵ In this way, I can demonstrate how simulation results change if the 33% share cap is applied at the CMA level instead of at the EA or REAG level.
- (142) The results based on the artificial auction with CMA-only licenses do not differ much from the original simulation results. The auction revenue would fall significantly in all scenarios: from 16% in the outright exclusion scenario to 8% in the scenario in which AT&T and Verizon are excluded from the CMA markets where their post-auction spectrum share would have been above 33% had they purchased 10 MHz of spectrum. When exclusion is made at the CMA-level, the degree of exclusion (and associated revenue reduction) based on post-auction shares after 10 MHz purchase in the auction is much higher than the exclusion with the actual set of AWS spectrum licenses (see footnote 52).

⁶⁵ Counties from one CMA can be included in several EAs or REAGs. In such cases, I allocate all of a CMA's counties to an EA or a REAG that accounts for the highest population share in this CMA.

- (143) Figure 21 and Figure 22 report simulation results of exclusion in an artificial AWS auction with CMA-only licenses. Auction revenue would fall nearly 16% in an outright scenario, and 10-14% in share capped exclusion scenarios.

Figure 21 Simulated auction revenue change with artificial CMA-only AWS spectrum auction licenses in different scenarios of Verizon and AT&T exclusion

Simulation scenarios	Verizon	AT&T	T-Mobile	SpectrumCo (Sprint)	Other	Total
Excluded outright	-100.0%	-100.0%	33.8%	16.4%	5.2%	-15.9%
Excluded if pre-auction share is greater than 33%	-93.6%	-79.1%	30.9%	14.2%	4.1%	-14.1%
Excluded if post-auction share after 20 MHz purchase is greater than 33%	-55.1%	-79.0%	17.4%	14.3%	4.0%	-10.3%

Source: Calculations based on the FCC data and documentation.

- (144) The results based on the auction with CMA-only licenses show that Verizon and AT&T, even under capped exclusion, lose the bulk of their MHz*POPs. These MHz*POPs are captured by T-Mobile and SpectrumCo.

Figure 22 Simulated percent change in the MHz*POP with CMA-only AWS spectrum auction licenses in different scenarios of Verizon and AT&T exclusion

Simulation scenarios	Verizon	AT&T	T-Mobile	SpectrumCo (Sprint)	Other
Excluded outright	-100.0%	-100.0%	64.3%	23.3%	10.5%
Excluded if current share is greater than 33%	-91.4%	-72.1%	57.1%	18.4%	6.8%
Excluded if share after 20 MHz is greater than 33%	-48.5%	-72.0%	33.3%	18.3%	6.1%

Source: Calculations based on the FCC data and documentation.

Appendix E. Modeling details for the simulated incentive auction

- (145) In this appendix, I provide an overview of the Vickrey mechanism as applied to the sale of multiple units, where buyers potentially desire more than one unit. I refer to this as the multi-unit Vickrey mechanism. I begin by discussing this mechanism in an environment where the auctioneer owns the items for sale. This is the “one-sided” setting. Then I discuss the mechanism in an environment like the Incentive Auction where the auctioneer must provide incentives for sellers to participate. This is the “two-sided” setting.
- (146) Let me first illustrate the multi-unit Vickrey mechanism in a *one-sided setting*—that is, where the auctioneer *owns the items to sell* (so the auctioneer does not have to induce sellers to reveal their willingness to pay). In a single-unit case, the auctioneer will open the sealed envelopes and award the item to the highest bidder (provided her bid exceeds the reserve price), but, using the Vickrey mechanism, the auctioneer will charge the winner the amount offered by the second-highest bidder.
- (147) In the case of multiple units for sale, buyers submit bids consisting of multiple amounts: a bid for the 1st unit, a bid for the 2nd unit, a bid for the 3rd unit, and a bid for the 4th unit. If there are, say, 4 units for sale, the auctioneer awards the items to the bidder(s) who have placed the 4 highest bids (this could be a single buyer whose bids placed in the top four spots in the ranking). The identification of the winners is thus an easy extension of the single-item set-up—the highest bids win.
- (148) The determination of the amount each winning bidder must pay for each unit she won is slightly more complex when more than one unit is being sold, but still follows quite straightforwardly from the single-unit set-up. In the single-unit set-up, the auctioneer can be thought of saying to the winner: “If you had not participated, I would have given the item to the second-highest bidder. Because she was willing to pay the amount she wrote in her envelope, I am now asking for that amount from you (unless the second-highest bid is below the reserve price, in which case you owe me the reserve price).”
- (149) In the multi-item set-up, consider for example a bidder who placed 2 of the top 4 highest bids. The auctioneer would say: “If you had not participated, two lower bids that did not make the top-4 list would have now made the top-4 to replace your bids. As a consequence, I am now charging you those two amounts for the two units you actually won (unless those lower bids that would replace your two bids are below the reserve price, in which case you owe me the reserve price).”
- (150) Vickrey’s mechanism induces the bidders to truthfully bid their valuations because it gives a bidder no incentive to lie about her valuation: by under-reporting her willingness to pay, a potential buyer only hurts her chances to be named the winner (her bid is less likely to make it to the top of the list),

but it does not reduce the amount she pays if she wins because that amount does not depend on her bid at all. It depends only on the nonwinning bids of other buyers.

- (151) Because my illustrative model pertains to a two-sided auction rather than a one-sided multi-unit Vickrey auction, the auctioneer will proceed as follows (see Loertscher and Mezzetti, 2013).
- (152) First, the auctioneer will call out a reserve price and ask buyers and sellers to bid, that is, to report their willingness to pay or to accept in exchange for the license (which they have an incentive to do). Once both sides have submitted their bids, the auctioneer will count how many sellers have submitted a bid below the reserve price: these are the units available for sale at that reserve price. Similarly, the auctioneer will determine how many units the buyers demand at the reserve price.
- (153) When the units offered at the reserve price are fewer than the units demanded (suppliers are on the “short side”), the auctioneer will pay each willing seller the reserve price; the auctioneer will then run a one-sided Vickrey auction to select the winning buyers and determine the price they will pay.
- (154) Each winning buyer (who could win one or more units) pays a “personalized” price for each unit won—as described above, the highest bid(s) that would have made the winning circle in her absence, or the reserve price, whichever is highest.
- (155) Conversely, when the units offered at the reserve price are more than the units demanded, the buy-side is the short side that determines how many units are traded. The auctioneer will collect the reserve price from each of them. The auctioneer will then run a one-sided Vickrey auction among the sellers to select the winners (those asking for the lowest payments), and pay them “personalized” prices — the next-highest request in a winner’s absence, or the reserve price, whichever is the lowest.
- (156) For each possible reserve price that the auctioneer could set between \$0.05 and \$0.95 (in increments of 5 cents), I have computed the average number of trades and corresponding average auction revenues the auctioneer can expect to realize.⁶⁶ These results are illustrated in Figure 15.
- (157) For the purposes of Figure 15, I have assumed that buyers demand up to 20 units while suppliers will offer only up to 10 units. Moreover, I have assumed that buyers are expected, on average, to be willing to pay more for any given unit, \$0.75, than the sellers are asking to give it up, \$0.50. Under these assumptions, an efficiency-driven auctioneer wishing to maximize the number of efficient transactions will use a reserve price well above \$0.50 (about \$0.80), inducing all but the extremely high valuing sellers to give up their units. Then the auctioneer will take advantage of high demand (at that reserve price, sellers will still be more likely than not on the short-side, i.e., demand at a price of \$0.80 likely exceeds supply) to assign those units to buyers valuing them more than the reserve price via the Vickrey mechanism among buyers.

⁶⁶ This is based on 5,000 random draws for the sellers’ and the buyers’ valuations.

- (158) An auctioneer can increase expected auction revenue at the expense of efficiency by using a lower reserve price. The lower reserve price reduces the number of trades, but allows the auctioneer to collect higher prices from the buyers, who on average will be on the long-side competing for those fewer sales in most or all of the random draws. In my simulation, the highest expected revenue (the top-left point on the blue curve) that can be achieved occurs when the auctioneer uses a reserve price of approximately \$0.40. While only 4 units are sold on average in this case, the “personalized” prices that the auctioneer can extract from each buyer—the expected 5th highest valuation, the first unit that does not make the top 4—is about \$0.90, yielding a $\$0.50 = \$0.90 - \$0.40$ unit margin per sale and \$2.00 in auction revenues. By using a high reserve price, the auctioneer acts like a profit-maximizing monopolist that restricts the quantity traded in order to collect high margins.