Bidding and Prices in the AWS-3 Auction

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Summary

The FCC's AWS-3 spectrum auction raised revenues in excess of $44 billion—a new historic high. Our analysis demonstrates that the auction's results largely line up with the bidding strategies one would expect of the top four bidders in this auction. In particular, the results demonstrate the high value AT&T and Verizon, the two largest winners of paired broadband spectrum in the auction, have for mid-band AWS-3 spectrum. The auction results similarly demonstrate the premium AT&T and Verizon attached to the availability of contiguous 20 MHz blocks of mid-band spectrum in the H+I blocks or the J block. Thus, AT&T and Verizon's own bidding strategies call into question their claims that the AWS-3 auction's success somehow demonstrates the irrelevance of a pro-competitive spectrum reserve for the 600 MHz auction. If anything, the results in the AWS-3 auction *reinforce* the need for a pro-competitive spectrum reserve in an auction of low-band 600 MHz spectrum, for which smaller carriers will have a greater need.

The motivation for the spectrum reserve in the 600 MHz (low-band) auction is unrelated to the outcome of the AWS-3 (mid-band) auction. Consistent with the national advertising campaigns of AT&T and Verizon, the largest carriers enjoy a deep coverage advantage. This coverage advantage has been achieved in part with their dominant position in low-band spectrum. Low-band spectrum enables better coverage in difficult terrain, rural areas, and within buildings. AT&T and Verizon benefit from this competitive advantage and have an incentive to avoid losing this advantage in the 600 MHz spectrum auction. This incentive to foreclose competition in both urban and rural areas is the predominant motivation for the FCC's competition policy in the 600 MHz spectrum auction, which wisely reserves some blocks for carriers without access to more than one-third of the low-band spectrum in a given geographic area. The reserve will likely motivate participation by smaller carriers in the low-band auction by preventing the foreclosure of competition by AT&T and Verizon.

Our analysis also calls into question claims that designated entity bidding credits available in the AWS-3 auction somehow came at the expense of the taxpayer. Rather, by increasing the collective pricing pressure in the auction, the cost of these bidding credits fell on the two largest bidders, AT&T and Verizon—not on taxpayers. Similarly, our analysis dispels the notion that SNR Wireless License Co, LLC (SNR) and Northstar Wireless, LLC (Northstar), the designated entities (DEs) that partnered with Dish, armed with over $3 billion in bidding credits, were the primary reason that competitive carriers won comparatively fewer licenses in the auction. In actuality, the effect of the DE's bidding credits was to

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further propel the collective pricing pressure in the auction upward, which accounts for competitors' lower spectrum winnings relative to other bidders.

In sum, the AWS-3 auction demonstrates a strong demand for spectrum. The auction results largely were driven by the largest carriers' greater needs for contiguous, mid-band spectrum in their networks, driving their corresponding bidding strategies. The AWS-3 auction results in no way undercut the need for pro-competitive measures like a spectrum reserve in the 600 MHz auction.

Introduction

There is much policy debate about the AWS-3 auction.[2] This is to be expected given the enormous stakes involved and the amount of money raised. The Broadcast Incentive Auction, which is less than one-year away, will shape the mobile wireless industry for at least a decade. The purpose of this paper is to provide an objective data-driven analysis of the AWS-3 auction, and avoid the misleading statements that fill the policy debate. Here we present facts and analysis of the auction and dispel many myths from the policy debate.

Our analysis is based on the public auction data[3] and our extensive experience analyzing major spectrum auctions over the last twenty-one years (several of which are in the References at the end of this paper). Our main focus is the AWS-3 auction outcome—who won and at what prices. We then show and explain the properties of the prices with a simple regression model and other analysis.

Background

Congress authorized a series of spectrum auctions in 2012 to meet growing domestic demand for wireless broadband,[4] including a projected ten-fold increase in smartphone network traffic between 2013 and 2019.[5] In adopting rules for the auction of the AWS-3 spectrum (Auction 97), the FCC similarly recognized that "[w]ireless broadband is a critical component of economic growth, job creation, and global

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[2] For opposing views on whether the AWS-3 auction yielded a successful outcome, *see, e.g.*, John Legere, *Speak Up for America's Wireless Future*, T-MOBILE NEWSROOM, 18 February 2015; Ben Munson, *T-Mobile CEO Rallies Consumers against AT&T, Verizon*, WIRELESSWEEK, 18 February 2015; Joan Marsh, *Lessons from Auction 97 for Future Auctions*, AT&T PUBLIC POLICY BLOG, 20 February 2015; Phil Goldstein, *AT&T Slams Dish's AWS-3 Auction Bidding Strategy, Suggests Rule Changes for Incentive Auction*, FIERCEWIRELESS, 20 February 2015; Joan Marsh, *Auction 97—More Lessons for Future Auctions*, AT&T PUBLIC POLICY BLOG, 4 March 2015 ("Marsh, *More Lessons for Future Auctions*"); Phil Goldstein, *AT&T Tussles with T-Mobile over AWS-3 Spectrum Auction Results*, FIERCEWIRELESS, 5 March 2015; FCC Commissioner Michael O'Rielly, *AWS-3 Auction: Lessons Learned*, FCC BLOG, 27 March 2015.

[3] *See Auction 97 Full Information Round Results Files*, FCC.

[4] *See* Middle Class Tax Relief and Job Creation Act of 2012, Pub. L. No. 112-96, 126 Stat. 156 (2012) ("Spectrum Act"), codified at 47 U.S.C. § 1401 et seq.

[5] *Id.*

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competitiveness" and that "consumers are increasingly using wireless broadband services to assist them in their everyday lives."[6]

The AWS-3 auction was a highly-anticipated simultaneous, multiple-round auction of mid-band spectrum including 50 MHz of paired spectrum (1700 MHz uplink and 2100 MHz downlink) and 15 MHz of unpaired uplink spectrum (1700 MHz).[7] Table 1 shows the band plan and licenses auctioned. The unpaired spectrum was sold as two blocks (A1 of 5 MHz and B1 of 10 MHz) both partitioned in 176 Economic Area (EA) licenses each.[8] The paired spectrum was sold in four blocks; G was a 5+5 MHz block partitioned into 734 Cellular Market Area (CMA) licenses, H and I were 5+5 MHz blocks each partitioned into 176 EA licenses, and J was a 10+10 MHz block partitioned into 176 EA licenses.[9] The paired spectrum will be used by wireless carriers most likely with LTE technology, which has been adopted worldwide as the latest mobile wireless communication standard. Altogether there were 1,614 licenses up for auction.[10]

Table 1: AWS-3 band plan and licenses

Block	Frequencies (MHz)	Total bandwidth	Pairing	Geographic partition	Number of licenses
A1	1695-1700	5 MHz	unpaired	EA	176
B1	1700-1710	10 MHz	unpaired	EA	176
G	1755-1760/2155-2160	10 MHz	2 x 5 MHz	CMA	734
H	1760-1765/2160-2165	10 MHz	2 x 5 MHz	EA	176
I	1765-1770/2165/2170	10 MHz	2 x 5 MHz	EA	176
J	1770-1780/2170-2180	20 MHz	2 x 10 MHz	EA	176

The auction began 13 November 2014 and ended 29 January 2015 after 341 bidding rounds.[11] Total winning bids were $44.9 billion gross or $41.3 billion net.[12] Consistent with spectrum auctions worldwide, the paired spectrum sold for a substantial premium over the unpaired spectrum. Paired spectrum at $2.72/MHzPop sold for more than five times the price of unpaired spectrum at $0.52/MHzPop.[13]. We

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[6] Amendment of the Commission's Rules with Regard to Commercial Operations in the 1695-1710 MHz, 1755-1780 MHz, and 2155-2180 MHz Bands, GN Docket No. 13-185, *Report and Order*, 29 FCC Rcd 4610 ¶ 3 (2014) ("AWS-3 Report and Order").

[7] *See* Auction of Advanced Wireless Services (AWS-3) Licenses Scheduled for November 13, 2014; Notice and Filing Requirements, Reserve Prices, Minimum Opening Bids, Upfront Payments, and Other Procedures for Auction 97, AU Docket No. 14-78, *Public Notice*, DA 14-10185, 29 FCC Rcd 8386 ¶¶ 6-8 (2014) ("AWS-3 Public Notice").

[8] *See id.* at ¶ 8, Table 1.

[9] *See id.*

[10] *See id.* at ¶ 6.

[11] *See Auction 97 Full Information Round Results Files*, FCC.

[12] *See* Auction of Advanced Wireless Services (AWS-3) Licenses Closes; Winning Bidders Announced for Auction 97, *Public Notice*, DA 15-131, Attachment A (2015) ("AWS-3 Winners PN").

[13] *See* Peter Cramton et al., *Design of the Reverse Auction in the Broadcast Incentive Auction*, 12 March 2015 ("Cramton Report"), *attached to* Comments of Expanding Opportunities for Broadcasters Coalition, AU Docket No. 14-252, GN Docket No. 12-268, 12 March 2015.

focus on the paired spectrum, especially since it is the paired spectrum that is relevant in the 600 MHz auction.

Auction dynamics

A simultaneous, multiple-round ascending auction consists of a number of bidding rounds, separated into stages. At each new stage a higher activity requirement is imposed. The AWS-3 auction had four stages with activity requirements of 80, 95, 98, and 100 percent.[14] In each round, a bidder must meet the activity requirement by being active with a high bid or a new bid on the required percentage of the bidder's eligibility, or the bidder's eligibility to bid in future rounds is reduced to the level bid.
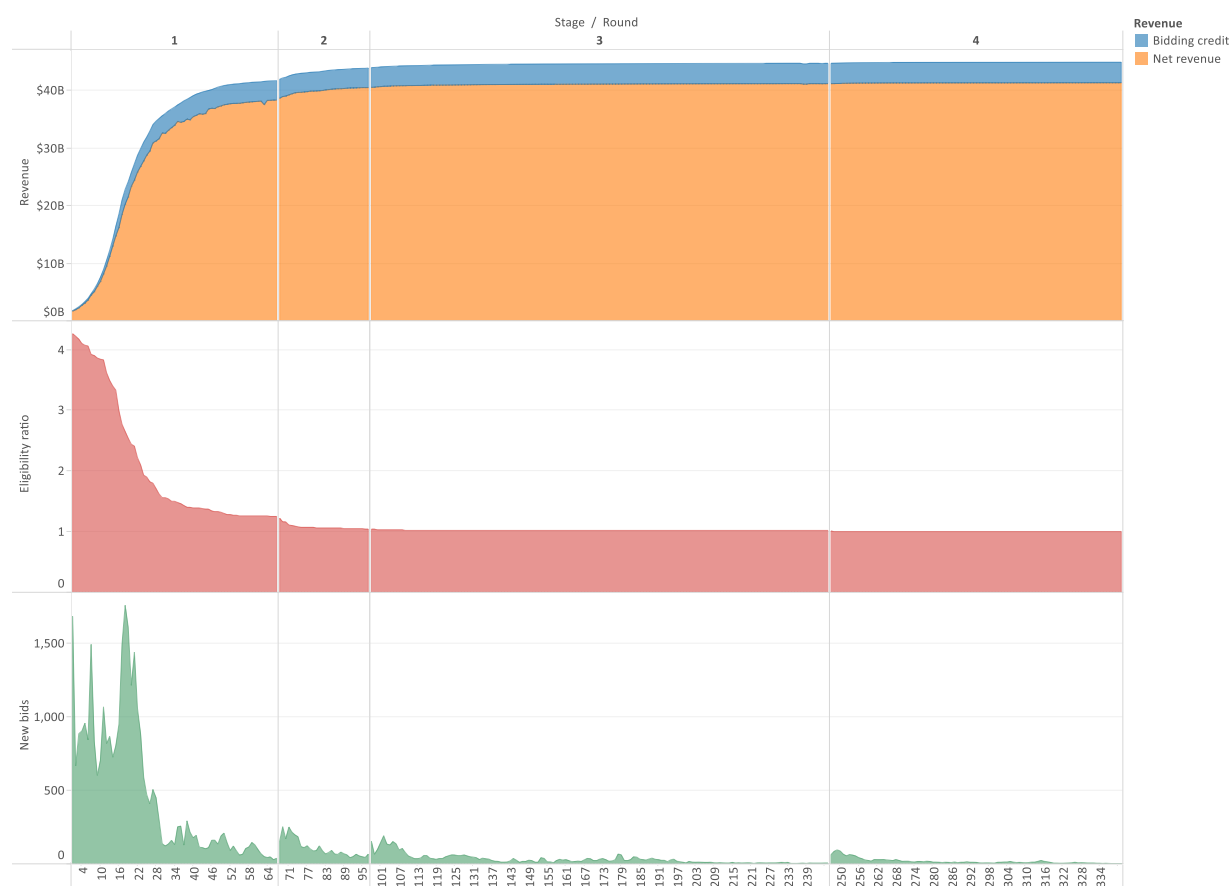

Figure 1: New bids, eligibility ratio, and revenues by round

Figure 1 shows three important statistics by round. The bottom panel in green shows the number of new bids. New bids initially were on the order of 1,000 new bids per round; moreover, this activity was especially concentrated on the larger, more valuable licenses. By round 40, the number of new bids—the source for price increases—dropped by a factor of 10 to about 100 new bids per round or less. Bidding

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[14] The AWS-3 PN only proposed 2 stages with activity requirements of 80 percent and 95 percent; however, the FCC added additional stages toward the end of auction. An online appendix compiles all AWS-3 auction announcements from the FCC auction bidding system. This includes announcements of stages 3 and 4.

would briefly tick up with each stage transition, where bidders holding back as allowed by the activity rule were forced to bid a higher percentage of their eligibility or lose it. The middle panel in red shows the eligibility ratio. The auction can be thought of as a game of musical chairs. Initially there are too many people (demand) and too few chairs (supply); as the music plays, however, prices increase, which causes demand to fall. Eventually, demand falls to the level where it just balances supply—an eligibility ratio of one. At this point the music stops and the auction is over. Consistent with other spectrum auctions, initial demand was initially high (over four times supply), but in early rounds prices went up quickly and demand fell rapidly. By round 40, the eligibility ratio was down to 1.39 and auction revenues were already at $40 billion. The top panel shows these revenues; the orange is revenues net of bidding credits and the blue is the amount of the bidding credits, so adding the two gives gross revenues.
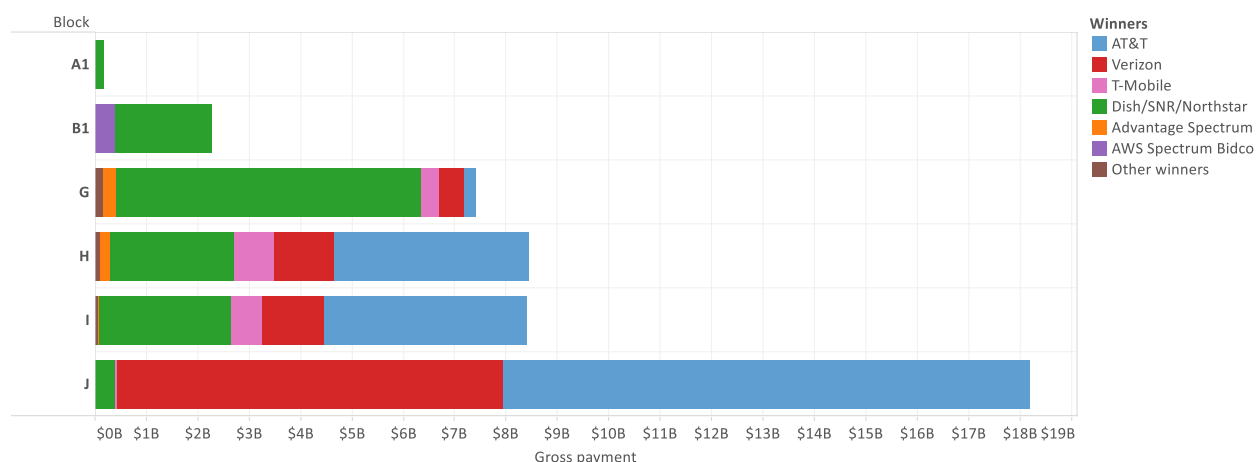
Who won and at what prices

Figure 2: AWS-3 winners by block and gross payments

Figure 2 shows the winners by block together with gross payments.[15] The fact that the block J had the highest price ($2.91/MHzPop vs. $2.69 for H and I and $2.37 for G) is a reflection of the synergies that come with greater bandwidth. Assuming the spectrum is being used efficiently, a carrier with 10+10 MHz has more than double the capacity and speed than a carrier with 5+5 MHz. This complementarity is a feature of LTE technology.[16] Focusing just on the largest bidders, the bidding of three parties—AT&T (blue), Verizon (red), and SNR and Northstar (collectively)[17] (green)—was largely responsible for the outcome in the paired blocks. By contrast, the next largest bidder, T-Mobile, was a much smaller winner,

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[15] Two entities in which Dish has 85 percent ownership each received a 25 percent discount as "very small bidders" eligible for bidding discounts. *See* Steven Davidoff Solomon, *How Loopholes Turned Dish Network Into a 'Very Small Business'*, N.Y. TIMES, 24 February 2015; Thomas Gryta et al., *Dish Network Surprise Winner In Spectrum Auction*, WALL STREET JOURNAL, 30 January 2015.

[16] The capacity of a contiguous 10+10 MHz is 20 percent higher than with two 5+5 MHz licenses. This is due in part to the better statistical multiplexing possible using the wider 10+10 MHz carrier. See FCC, "The Broadband Availability Gap," OBI Technical Paper No. 1, April 2010.

[17] Throughout this paper, we combine the bidding activity of SNR Wireless License Co, LLC and Northstar Wireless with Dish, as the three entities participated under a joint bidding arrangement disclosed to the FCC in Dish's auction application.

with total expenditures less than one-fifth those of either Verizon or SNR and Northstar (collectively), the second- and third-largest bidders in the auction.

The nationwide average price for the paired blocks was $2.72/MHzPop, about three times higher than investment banking estimates before the auction began.[18] Although the prices were high relative to recent U.S. spectrum auctions, AWS-3 auction prices remain much lower than the prices paid in Germany and the U.K. in 2000 during the tech bubble, which were over €5/MHzPop (about $6/MHzPop), more than double the AWS-3 prices.
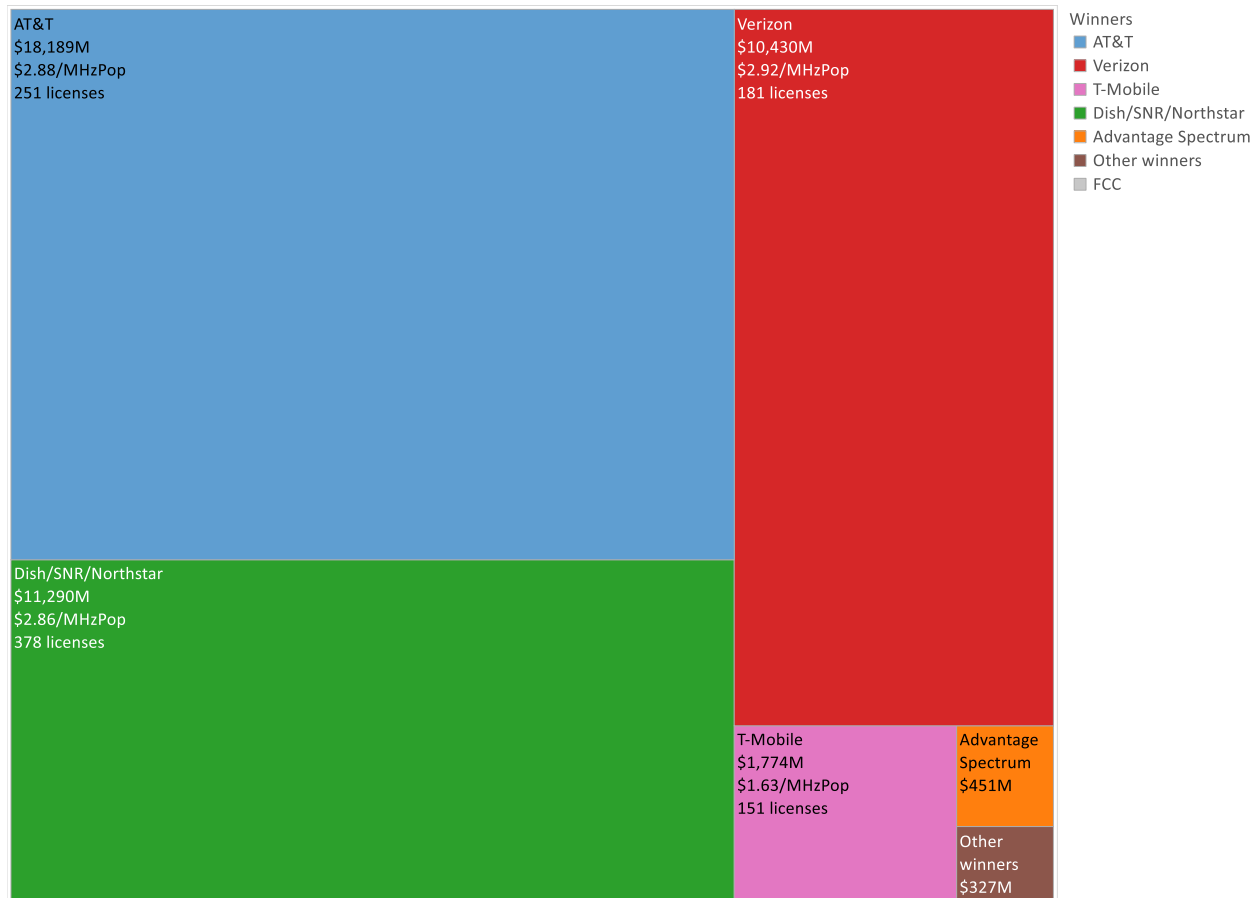

Figure 3: AWS-3 winners for paired blocks

Figure 3 shows the winners for the paired blocks. The area of each rectangle is the bidder's contribution to gross revenues. Measurements of a bidder's contribution to gross revenue offer an excellent proxy for the bidder's price impact in the auction. The picture shows the dominant impact of AT&T, Verizon, and SNR and Northstar (collectively), in driving prices. Table 2 shows the revenue shares. The top-three bidders—AT&T, Verizon, and SNR and Northstar (collectively) —bid 94 percent of the auction revenues. T-Mobile played a more minor role contributing just 4 percent to revenues and all other bidders contributed the remaining 2 percent. We use the gross bids of SNR and Northstar, the two designated

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[18] *See* Phil Goldstein, *AWS-3 Spectrum Auction Primer: What You Need to Know Before the Bidding Starts*, FIERCEWIRELESS (Nov. 12, 2014).

entities that partnered with Dish, in assessing price impact, since their impact on prices was through their gross bids, as none of the other large bidders received bidding credits.

Table 2: AWS-3 winners and revenue shares for paired blocks

Winners	Price ($/MHzPop)	Revenue (billion $)	Revenue share	Cumulative share
AT&T	$2.88	18.2	43%	43%
Dish/SNR/Northstar	$2.86	11.3	27%	69%
Verizon	$2.92	10.4	25%	94%
T-Mobile	$1.63	1.8	4%	98%
Others	$1.09	0.8	2%	100%
Total	$2.72	42.5	100%	

Competitive carriers have a strong need for low-band spectrum to improve coverage in buildings, in difficult terrain, and in less densely populated areas. Given the financial constraints of competitive carriers in relation to AT&T and Verizon, it appears competitive carriers may have sought to conserve spending on mid-band spectrum in the AWS-3 auction to retain financial flexibility to acquire low-band spectrum in the 600 MHz auction.

The aggressive bidding by AT&T and Verizon in the AWS-3 auction makes perfect sense. These dominant carriers benefit from a pre-existing coverage layer comprised of their low-band cellular and 700 MHz holdings and can selectively acquire mid- and higher band spectrum to satisfy capacity needs where needed. Unable to employ spectrum to expand capacity, would-be rivals are forced to either operate with higher costs relative to the dominant carriers, reduce the quality of their service offerings, or both.
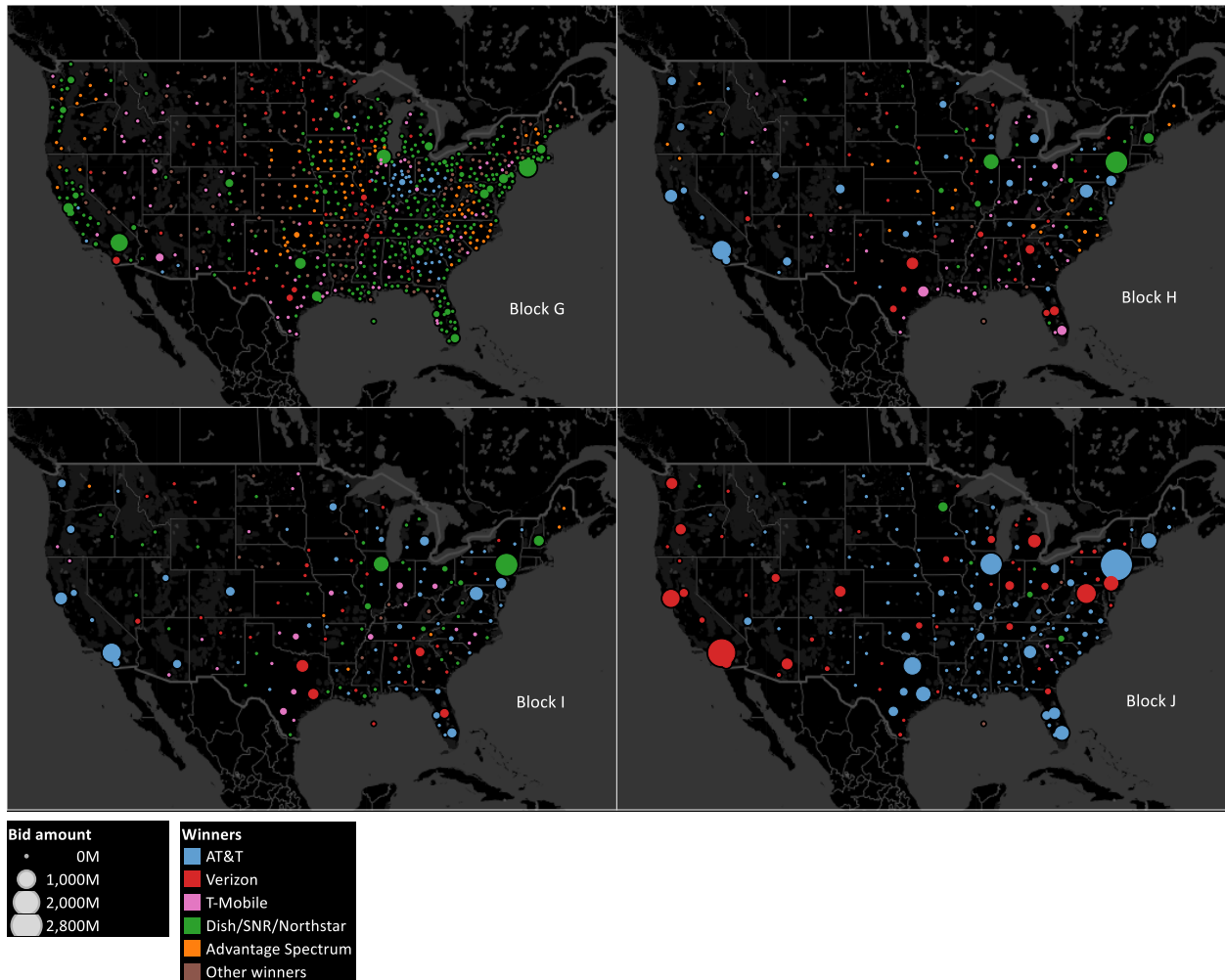
Figure 4: AWS-3 winning bidder and bid by paired block

Figure 4 shows the largest AWS-3 winners for each paired block. The color indicates the winning bidder; the size of the circle indicates the winning bid amount. AT&T (blue) stood out as the most aggressive bidder. SNR and Northstar (green) predominantly won the G block, although it also won in many key markets in the H and I blocks, such as New York and Chicago. AT&T was the big winner of the J block in the East, whereas Verizon (red) won the J block in the West. AT&T won the H and I blocks in the West. T-Mobile (magenta) bought less expensive licenses in the G, H, and I blocks. The big drivers of spending are the top-four markets—New York, Los Angeles, Chicago, and San Francisco. AT&T, Verizon, and SNR and Northstar bid aggressively for all of these markets.

Counting licenses won is misleading

One thing that should be clear from Figure 4 is that counting the number of licenses won as a measure of price impact is completely meaningless. A bidder can win a large number of licenses and have little price impact or win relatively few and have a large price impact. It all depends on which licenses are won. To emphasize this basic point, Figure 5 shows a histogram of the number of licenses in price bins with $0.50 increments. Roughly one-half (774) of the licenses have prices below $0.50/MHzPop; these licenses

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contribute less than $1 billion to auction revenues—in other words, the bottom 48 percent of the licenses contribute 2 percent of the revenue. At the other end of the distribution, the top 2 percent of licenses (the 26 largest) had prices above $4.50/MHzPop and contributed 38 percent of the revenue ($16.1 billion).
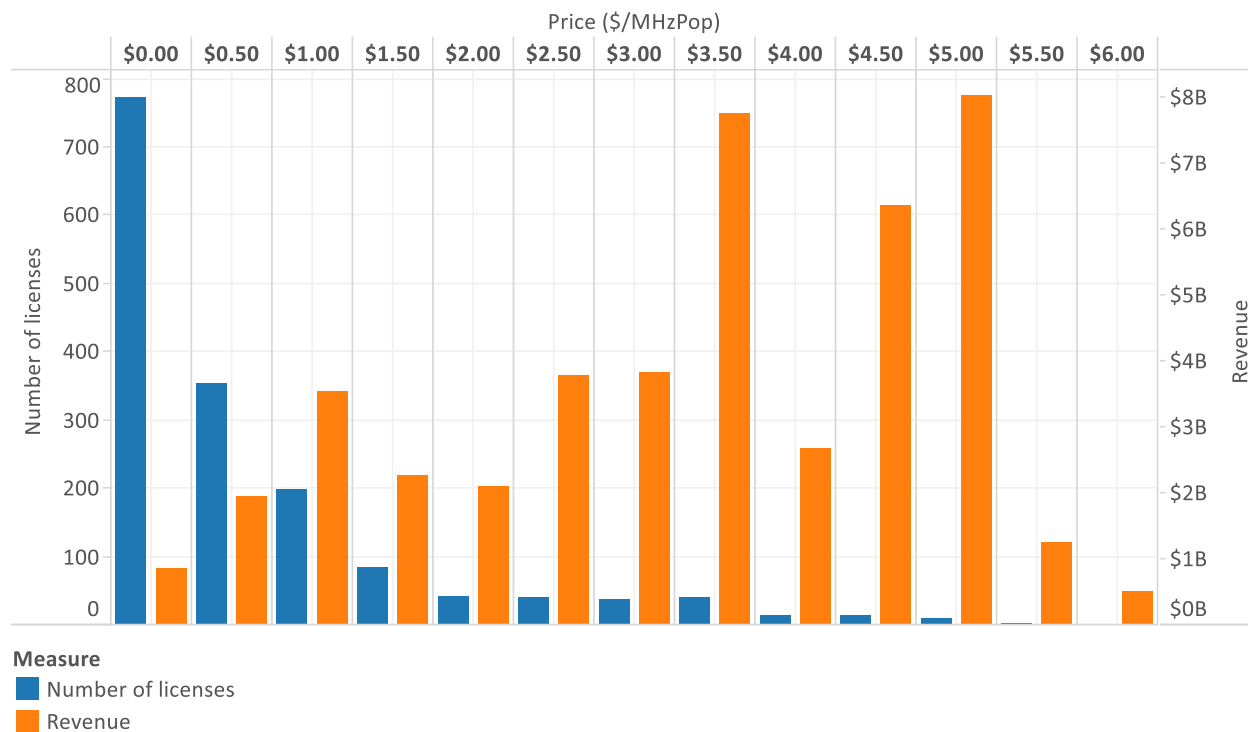

Figure 5: Histogram of license prices ($/MHzPop) and contribution to auction revenue

The paired blocks are largely fungible

Figure 6 shows the AWS-3 prices by block. Prices ranged from $6.11/MHzPop (dark red) to near zero (white). Notice how the largest markets, such as New York and Los Angeles, command the highest prices. This is an important feature of all spectrum auctions. Not all MHzPop are equal. Licenses in major markets predictably command higher prices. Also notice how the pricing relationship across markets is consistent across blocks. That suggests that the blocks are largely fungible, which intuitively makes sense for an interoperable band like AWS-3. One limitation in substitution across blocks is the different geographic partition between the G block (CMA) and the other blocks (EA). This likely is the reason that the G block sold for slightly less relative to the other blocks.
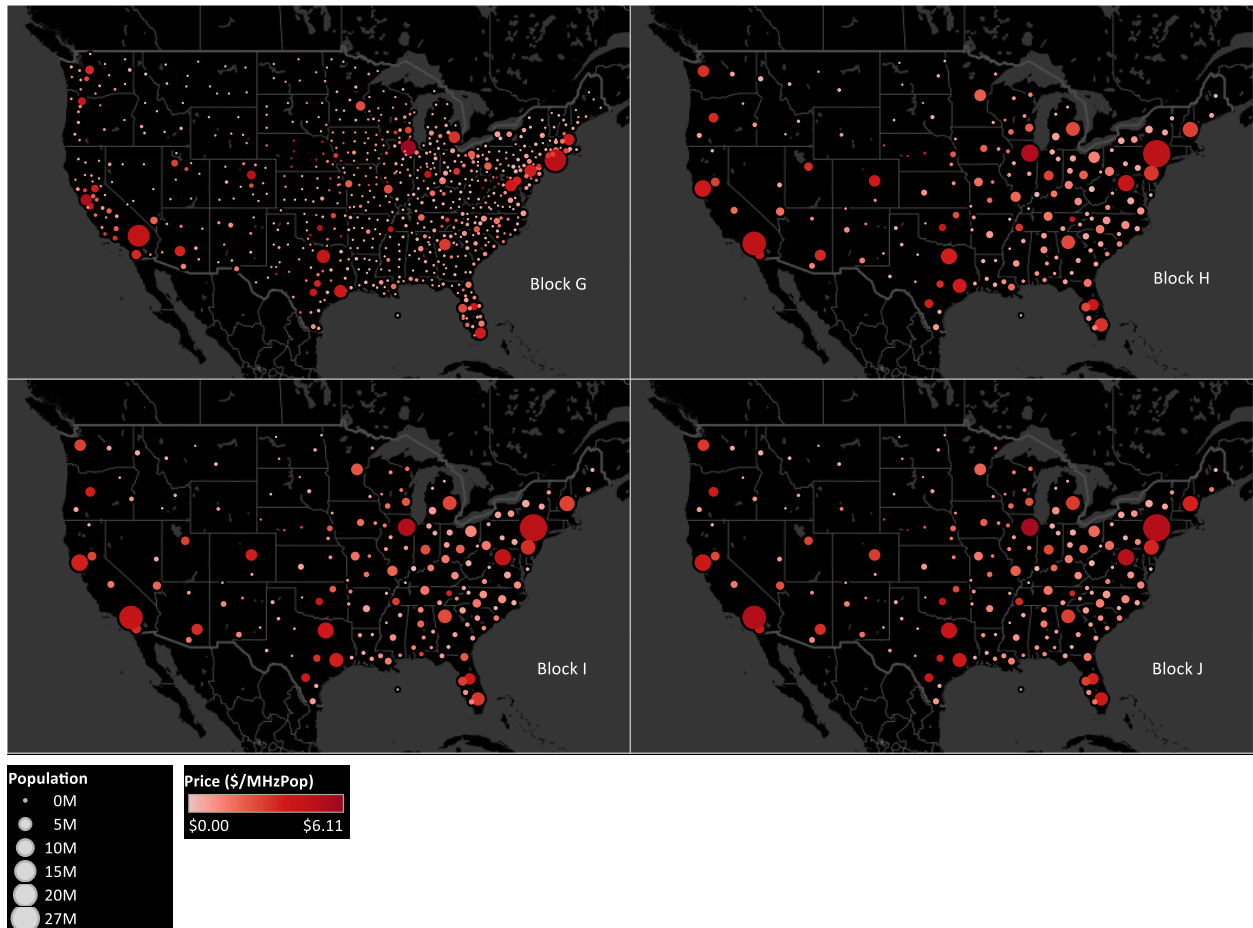
Figure 6: AWS-3 price and population by paired block

Although Figure 6 provides some visual evidence that bidders substitute across the paired blocks, this substitution across interoperable blocks is so important to our message that we examine the issue in greater detail. First, Table 3 shows the correlation of license prices between any two paired blocks. In all cases the correlation is greater than 0.925. This is an extremely high level of correlation implying that blocks are largely fungible.

Table 3: Correlation coefficients of license prices between paired blocks

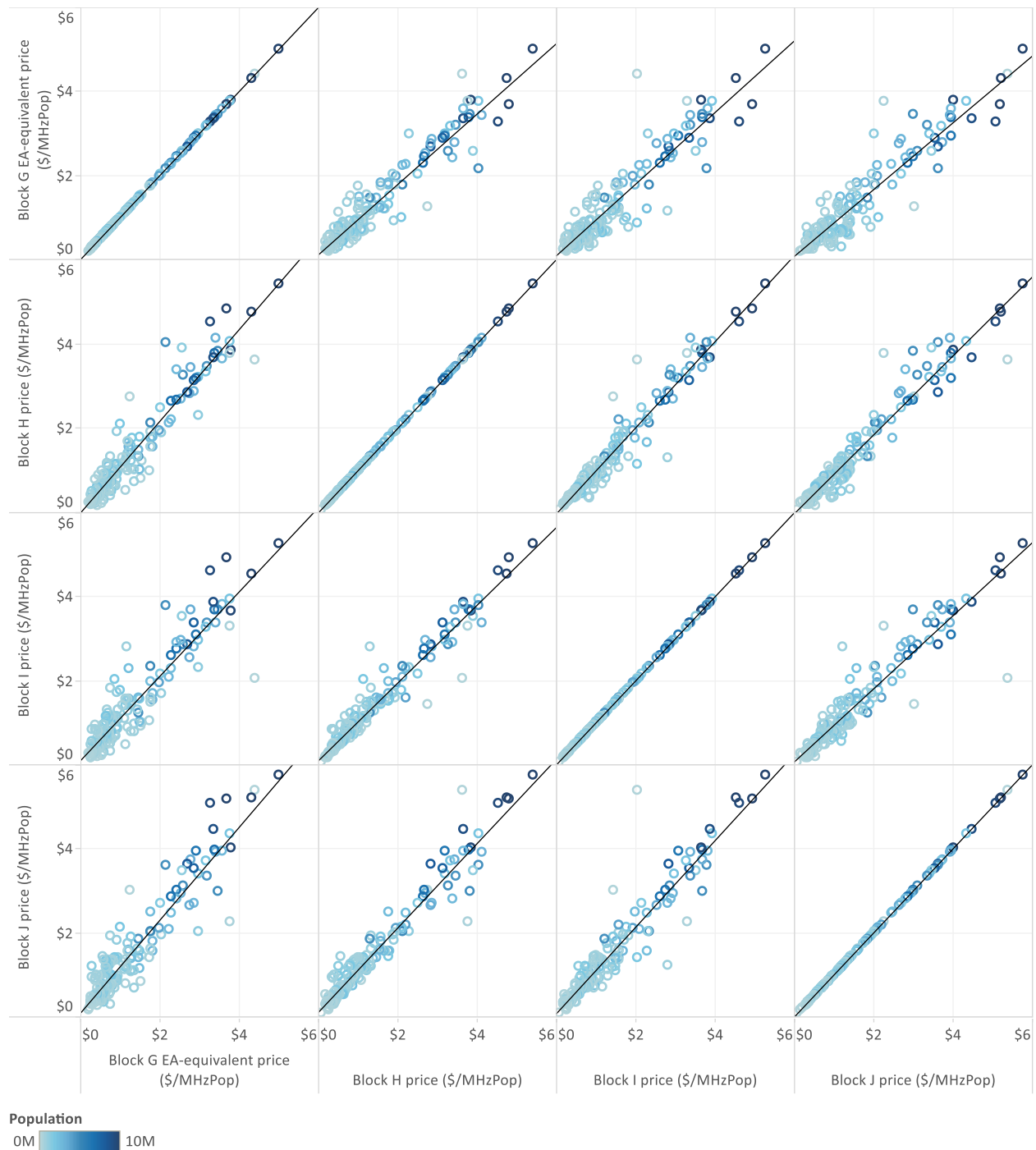|	Block G (EA-equivalent)	Block H	Block I
Block H	0.954		
Block I	0.925	0.972	
Block J	0.937	0.968	0.946

Figure 7: Plots of license price ($/MHzPop) between paired blocks

Figure 7 plots license prices between all combinations of paired blocks. For each block pair, the trend line is also shown. The plots also indicate the license population with color—larger markets are darker blue. In all cases the high level of correlation is seen with the vast majority of licenses falling on or near the trend line. There are a few outliers, but these are exceptional. Since Block G was auctioned with a different geographic partition (CMA rather than EA), we had to create an EA-equivalent price. We did this as follows: (1) we decomposed the Block G winning bid to county in the corresponding CMA by population,

then we (2) aggregated the county-distributed winning bid up to the EA level to calculate the EA-equivalent price.

A simple regression explains relative prices by market

In our final piece of analysis, we explain prices with a simple—yet remarkably powerful—regression model. The model is designed to explain relative winning bid amounts across service areas. There is a single critical variable, population share, which is easily calculated for any spectrum auction with multiple services areas, regardless of the geographic scheme. The simplest model is a linear one that only includes population share as the predictor of relative bid amounts, or bid shares = (license's winning bid)/(total winning bids for all licenses in block). A better model includes the square of population share to recognize that the larger markets tend to be more valuable.

Table 4: AWS-3 relative price model

Variable	(1)	(2)	(3)	(4)	(5)
Population share	1.645	1.180	1.093	1.102	1.415
	(0.012)	(0.020)	(0.017)	(0.025)	(0.022)
Population share^2	-	8.773	6.518	7.045	6.129
		(0.333)	(0.300)	(0.394)	(0.562)
Top-4 market	-	-	0.018	0.013	0.018
			(0.001)	(0.001)	(0.001)
Constant	-0.002	-0.001	-0.001	-0.002	-0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Blocks	G, H, I and J	G, H, I and J	G, H, I and J	H, I and J	G
Adjusted R-squared	0.937	0.960	0.971	0.979	0.981
Observations	1,260	1,260	1,260	528	732

Note: standard errors are shown in parentheses.

Table 4 shows the both the linear model (1) and the quadratic model (2) for the paired blocks of the AWS-3 auction. The quadratic model fits significantly better than the linear model. Model (3) improves on the quadratic with a top-4 market proxy (New York City, Los Angeles, Chicago, and San Francisco). This model performs even better; the top-4 markets have a bid premium beyond what the quadratic term provides. Model (4) is similar to (3) but only includes the three blocks (H, I, and J) that use the EA partition; similarly, model (5) includes only the block G, which has the CMA partition. It seems quite plausible that a different partition scheme would have different regression coefficients. Models (4) and (5) confirm this possibility.
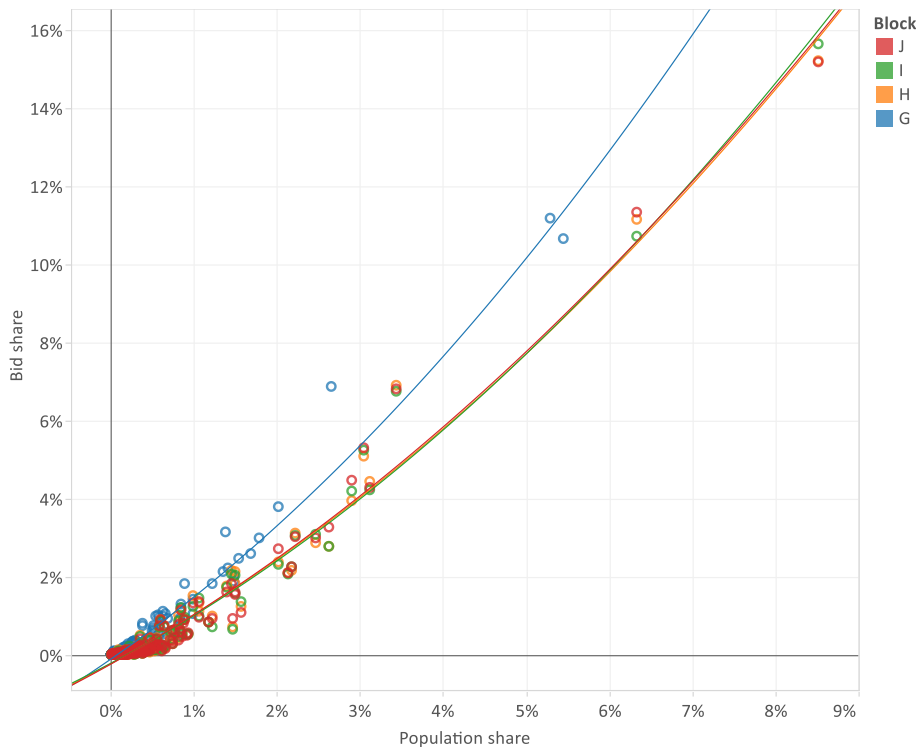
Figure 8: Quadratic model and winning bid shares by block

Figure 8 shows the performance of the quadratic model for each of the blocks plotting the model and actual bid shares, where bid share = (license's winning bid)/(total winning bids for all licenses in block). The model explains relative prices well. Notice that the model is nearly identical for each of the EA blocks (blocks H, I, and J), whereas for the G block with the CMA partition, the model coefficients are slightly different as a result of the different geographic scheme.

Our earlier analysis showed that blocks were highly substitutable. The regression model shows that there is also substitution across service areas, since prices across service areas are readily explained with a simple regression model. If substitution across service areas were poor, then we would expect our simple regression model to perform less well because price differences across markets would depend much more on idiosyncratic needs of the bidders.

Dispelling the myths in the policy debate

We now turn to the myths that have appeared in the policy debate. Although we doubt that our paper will discourage policy advocates from making misleading statements, our hope is that this paper will at least set the record straight.

Myth 1: Competitive Carriers, in particular T-Mobile, were largely in competition with Dish for the licenses it won

AT&T argues that Dish was the reason T-Mobile did not win more spectrum in the AWS-3 auction.[19] The argument is that Dish, by partnering with DEs, was often the bidder to push T-Mobile's bids higher and it was the DEs that often ended on top, with T-Mobile as the second-highest bidder. The problem with this argument is it ignores why SNR and Northstar were bidding against T-Mobile—typically the bids against T-Mobile were simply SNR and Northstar seeking out available fungible blocks. One cannot point to a single party as the cause for the higher prices; rather, it is the bidding of all parties, but especially the largest two bidders, that drove the prices to the final levels. Or, returning to the musical chairs analogy, SNR and Northstar were pushed off of the chairs by AT&T and Verizon, and then displaced the smaller competitive carriers. Even if AT&T only bids on the J block in a particular market, AT&T's aggressive repeated bidding on that block drives the prices higher on all the other paired blocks, given that the blocks are highly substitutable.

There is no question that it was the aggressive bidding of AT&T and Verizon in addition to SNR and Northstar that drove the prices in the AWS-3 auction to record levels. These bidders purchased 94 percent of the spectrum by value – spectrum that is highly fungible across the interoperable blocks. As a result, T-Mobile had to settle for winning less.

Myth 2: It's all about capacity

This has been an AT&T mantra for several years in policy circles.[20] It is AT&T's way of saying that there is no need for competition policy in the 600 MHz auction that would limit AT&T's purchase of the low-band spectrum, since "it's all about capacity, not coverage." In fact as everyone with a mobile device knows it is about coverage *AND* capacity. A mobile device is worthless without coverage, and coverage is a real issue for all consumers in all markets, regardless of carrier. This is obvious if one looks at the consumer advertisements from the largest incumbents, AT&T and Verizon. These advertisements repeatedly emphasize the wonderful network coverage of their brands. Consumers care about coverage and the reason why is that coverage often is an issue—even for AT&T and Verizon, even in the largest mobile markets like New York and Washington, DC.

The low-band spectrum that will be auctioned in next year's Broadcast Incentive Auction is ideally suited for coverage, given the propagation characteristics of the 600 MHz band that enables better coverage in less populated regions, areas with difficult terrain, and within buildings. AT&T and Verizon have considerable low-band spectrum on a national scale, which gives them a competitive advantage over their smaller rivals. The FCC rightly is concerned about the foreclosure of competition through excessive concentration of low-band spectrum.

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[19] Marsh, *More Lessons for Future Auctions*.
[20] *See, e.g., id*.

Myth 3: Bidding credits were used at the expense of taxpayers

With gross bids of $44.9 billion in the AWS-3 auction, bidders' investments in designated entities on its face have allowed for a potential discount of $3.6 billion. AT&T has portrayed these discounts as a taxpayer subsidy.[21] This is not accurate. Statements by AT&T and Verizon about the nature of the discount program are based on the false premise that Dish, in particular, would bid in the exact same way with or without the discount—that is, without the discount, Dish itself would bid for and win the same licenses at the same gross prices, increasing net auction revenues by the amount of the discount. Such an outcome is highly implausible as it assumes that Dish's demand curve for spectrum is vertical—at higher prices Dish demands the same quantity of spectrum. Such an assumption is absurd. The presence of the discount surely increased the appetite of Dish's investors to spend in the auction. Dish's substantial investment in spectrum (about $10 billion net of the discount) likely would have been much less without the discount and therefore the discount, rather than costing the American taxpayer, likely had the effect of increasing auction revenues considerably.[22] This assumption that Dish would spend less without the discount is simply saying that Dish's demand for spectrum is elastic—a one percent increase in price results in more than a one percent decrease in the quantity demanded. Then the discount leads Dish to spend more and the American taxpayer benefits from the Dish discount. The cost of the discount is more than 100 percent borne by the other bidders.

Conclusion

The AWS-3 auction was a highly successful auction for taxpayers as it raised over $41 billion and freed up 65 MHz of spectrum, but also demonstrates the potential perils to competition in the mobile wireless market. The competition fueled high revenues for taxpayers and reflected the high value of the scarce spectrum resource.

The high prices are readily explained by simple models. Arbitrage across the highly substitutable paired blocks kept all four paired blocks in line with one another—with a slight discount for the G block due to its different geographic partition and a slight premium for the J block due to synergies in speed and capacity of the larger block. Substitution across markets drove the relative prices in each service area to be explained with high precision by a simple model based largely on market size.

Despite the auction's fiscal success, the AWS-3 auction demonstrates the ability of the dominant incumbents, AT&T and Verizon, to bring many tens of billions of dollars in capital to a major spectrum auction. This is not surprising given the spectrum's enormous value and exponential growth in consumer demand fueled by ever-powerful devices. However, it does reinforce the need for competition policy. The FCC is wise to take competition policy seriously. AT&T and Verizon won over two-thirds of the paired spectrum in this auction. In the 600 MHz auction, the setting will be similar with the exception that competitive carriers, especially those with little low-band spectrum, will be much more eager to acquire the low-band spectrum and AT&T and Verizon will be much more eager to foreclose this possibility. The FCC has established a balanced approach for the 600 MHz auction that allows AT&T and Verizon to win

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[21] *Id.*

[22] This phenomenon, first explained in Ayres and Cramton (1996), has been seen in many spectrum auctions.

the substantial low-band spectrum they need, yet prevents them from foreclosing the disruptive competition that competitive carriers bring for the betterment of all consumers.

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