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George S. Ford, PhD
Thomas M. Koutsky, J.D.
Lawrence J. Spiwak, J.D.

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USING AUCTION RESULTS TO FORECAST THE IMPACT OF WIRELESS *Carterfone* REGULATION ON WIRELESS NETWORKS

Abstract: In the last year, many advocates have called for the imposition of *Carterfone* regulation on the wireless industry. The FCC partially heeded this call when it imposed "open platform" regulations on one substantial block of spectrum (the Upper C block) that was recently part of the record-setting 700 MHz auction. In the fourteen years that the FCC has performed spectrum auctions, never before has the FCC simultaneously auctioned similar spectrum licenses that are subject to two radically different regulatory regimes. In this BULLETIN, we utilize the results of this unique auction to show that applying similar "wireless *Carterfone*" regulation to all commercial wireless spectrum could suppress wireless infrastructure investment by $50 billion over the next decade, sharply reduce the profitability of wireless network services by 32%, and harm consumers. Because there are significant fixed and sunk costs involved with building and operating a wireless network, the estimated change in profitability could limit consumer choice by creating more highly-concentrated market. Indeed, applying such regulation across the board is likely to cause particular harm to small or medium-sized wireless firms by enhancing the role of scale economies in determining industry structure.

I. Introduction

Last month, in the largest spectrum auction in history in the United States, the Federal Communications Commission ("FCC") collected nearly $19 billion (in net bids) from the auction of 62 MHz of spectrum to be vacated by TV channels 52-69. The proceeds from this auction far

exceeded the $10.2 billion that Congress estimated would be raised, which demonstrates the tremendous potential this spectrum holds for the future of wireless services in America.[1] Immediately upon the closing of the auction, FCC Chairman Kevin J. Martin hailed the auction of this "700 MHz band" as "a record success" and, with respect to revenues raised, it was.[2]

But the auction results also carry an important message about the impact regulatory decisions can have upon the value of spectrum and perhaps ultimately on the future of the wireless telecommunications industry. Partially heeding calls to impose *Carterfone*[3] rules on the wireless industry, the 700 MHz auction was an experiment of sorts for "network neutrality," because over one-third of the spectrum auctioned (the 22 MHz Upper C block) was made subject to mandatory "open platform" regulations, while other auctioned licenses were unencumbered. Such a decision was a radical departure from prior auctions, since in the fourteen years the FCC has performed spectrum auctions, never before has the FCC simultaneously auctioned similar spectrum licenses that are subject to two radically different regulatory regimes. Verizon Wireless won the vast majority of these open platform licenses, paying $4.7 billion for licenses that cover the contiguous United States and Hawaii.[4] Chairman Martin called the decision to target only one block of spectrum for open platform regulation "a rare chance to promote innovation and consumer choice while writing on a clear slate."[5]

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[1] J. Silva, *214 Qualified to Bid in 700 MHz Auction*, RCR WIRELESS NEWS (Jan. 15, 2008) (available at: http://www.rcrnews.com/apps/pbcs.dll/article?AID=/20080115/FREE/148519229/1005/rss01).

[2] Statement by FCC Chairman Kevin J. Martin (Mar. 18, 2008) (available at: http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-280887A1.pdf) at 2. Chairman Martin also noted that the 700 MHz auction collected more than all other 68 auctions conducted by the FCC combined. *Id.* at 1.

[3] *Infra* nn. 11-12.

[4] *See* Federal Communications Commission, Public Notice, *Auction of 700 MHz Closes: Winning Bidders for Auction 73 Announced,* DA 08-595, (Mar. 20, 2008) (available at: http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-08-595A1.pdf), Attachment A (available at: http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-08-595A2.pdf).

[5] Remarks of FCC Chairman Kevin J. Martin, CTIA Wireless 2008 (Apr. 1, 2008) (available at: http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-281259A1.pdf) ("Martin Remarks") at 3. In voting for these open platform requirements on only a limited amount of the overall spectrum auctioned, FCC Chairman Kevin J. Martin anticipated that doing so would not "disrupt[] existing networks or business plans." Separate Statement of FCC Chairman Kevin Martin in Service Rules for the 698-746, 747-762 and 777-792 MHz Bands, WT Docket No. 06-150, Revision of the Commission's Rules to Ensure Compatibility with Enhanced 911 Emergency Calling Systems, CC Docket No. 94-102, Section 68.4(a) of the Commission's Rules Governing Hearing Aid-Compatible Telephones, WT Docket No. 01-309, Biennial Regulatory Review – Amendment of Parts 1, 22, 24, 27, and 90 to Streamline and Harmonize Various Rules Affecting Wireless Radio Services, WT Docket 03-264, Former Nextel Communications, Inc. Upper 700 MHz Guard Band Licenses and Revisions to Part 27 of the Commission's Rules, WT Docket No. 06-169, Implementing a Nationwide, Broadband, Interoperable Public Safety Network in the 700 MHz Band, PS Docket

(Footnote Continued….)

As a result, open platform regulations imposed on the Upper C block provide a unique opportunity to quantify some of the costs and benefits of this type of network neutrality mandate as they may be applied in the wireless context. In this BULLETIN, we show that the open platform requirements imposed by the FCC on the Upper C block cost the U.S. taxpayers approximately $3.1 billion in lost auction revenues. Because many providers—including Verizon, the "winner" of the Upper C block licenses—have already announced plans to open certain aspects of their wireless networks, it is important to note that the impact on auction revenues specifically measures the impact of a government-mandated open platform. Our estimates indicate that imposition of these regulatory mandates appear to reduce the expected profitability of the firm providing broadband wireless services using that spectrum by approximately 32%.

Our observations about the results of Auction 73 clearly have critical bearing on the question as to whether similar open platform—or "wireless *Carterfone*"—regulatory encumbrances should be imposed upon all commercial mobile spectrum. As discussed below, advocates seeking such regulation tend to ignore or trivialize the impact that these types of "wireless *Carterfone*" requirements would have on the business case for providing wireless broadband services. Our analysis suggests that imposing this type of regulation across all CMRS spectrum could chop profitability of wireless service providers substantially. Because there are significant fixed and sunk costs involved with building and operating a facilities-based wireless network, such a dramatic change in industry profitability could have a radical impact upon market structure and result in a more highly-concentrated market. We conclude that widespread application of mandatory wireless *Carterfone* regulations across all commercial mobile spectrum could reduce wireless network investment and potentially increase industry concentration. We estimate that applying the open platform regulations imposed upon the Upper C block across the board could cause a $50 billion decrease in wireless carrier network investment over the next ten years. Moreover, by shrinking and commoditizing the market for broadband wireless services, applying such regulation across the board is likely to cause particular harm to small or medium-sized wireless firms by enhancing the role of scale economies in determining industry structure.

Our findings are certainly not the end of this debate and their use warrants some caution. Lower auction revenues are not necessarily a sign of a policy failure and the FCC understood

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No. 06-229, Development of Operational, Technical and Spectrum Requirements for Meeting Federal, State and Local Public Safety Communications Requirements Through the Year 2010, WT Docket No. 96-86, Declaratory Ruling on Reporting Requirement under Commission's Part 1 Anti-Collusion Rule, WT Docket No. 07-166, *Second Report and Order*, FCC 07-132 (rel. Aug. 10, 2007) (available at: http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-07-132A2.pdf) ("*700 MHz Second Report and Order*").

perfectly well that the open platform requirements might reduce bids for the Upper C block licenses. Indeed, the FCC anticipated such a result, noting that "even if the limited requirements we impose today have some potential for reducing the monetary value and decreasing efficient use of spectrum in some respects, we believe that they are in the public interest."[6] If the open platform mandates imposed on the Upper C block incent new entry and more innovation in the handset and applications markets, then it may very well be that the consumer and producer welfare gains from that upstream entry and innovation will outweigh the harm to producers in the downstream wireless network industry.[7] The important task of policymakers is to balance competing concerns, but performing that balance of course requires that both the costs and benefits of any proposed regulation be measured.

Perhaps only time will tell whether the obligations placed on the upper C block will be worth the price, but our findings certainly point to caution in extending those requirements across all commercial wireless spectrum. The FCC stated that the approach it took with regard to the Upper C block "will allow both the Commission and the industry to observe the real-world effects of such a requirement."[8] Chairman Martin has noted that it is "premature" to mandate wireless *Carterfone* across all CMRS spectrum, stating that such a decision requires the "careful balancing of spurring innovation and consumer choice while encouraging infrastructure investment."[9] In this BULLETIN, we provide an important first step in making that assessment, by making a rough quantification of part of the impact that mandating wireless *Carterfone* regulations may have on the industry and consumers.[10]

II. The Debate over "Wireless *Carterfone*" and the 700 MHz Band Auction

Whether government should regulate how wireless companies support different mobile handsets and mobile applications on their networks has been the topic of considerable debate. Many consumer advocates, scholars and software companies have supported "wireless

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[6] *700 MHz Second Report and Order, supra* n. 5 at ¶ 215.

[7] *Id.* at ¶ 201 ("By fostering greater balance between device manufacturers and wireless service providers in this respect, we intend to spur the development of innovative products and services").

[8] *Id.* at ¶ 205. The FCC called its imposition of an open platform mandate on the Upper C block a "measured step," noting that "we cannot rule out the possibility that such a requirement may have unanticipated drawbacks as well." *Id.*

[9] Martin Remarks, *supra* n. 5 at 3.

[10] We note that our analysis is restricted to mandated "open platform" obligations. Wireless firms of course may choose to open some parts of their networks to handset and software applications, but a mandated "open platform" includes government establishment and enforcement of terms and conditions. Due to its coercive application, a governmental mandate can have a more far-reaching impact upon business plans and profitability.

Carterfone" rules,[11] drawing inspiration from a set of court and regulatory decisions relating to attachments to the monopoly wireline telephone network that date back to the 1960's.[12] Some of these advocates admit that the close relationships among equipment and service providers can increase value and efficiency.[13] But, to proponents of such regulation, the marriage of wireless devices with service offerings is generally viewed as an anti-competitive, or at least anti-consumer, practice of wireless service providers. Indeed, many have even called for an outright ban on any bundling of wireless services and devices. These advocates assert that allowing wireless network providers to lock customers into long-term contracts in exchange for a lower-priced bundle of service and handsets has the effect of unreasonably limiting the proliferation of wireless devices or applications that might otherwise create service substitution or revenue cannibalization.[14]

In response to proposals made by Google and others, in August 2007 the FCC required that the 22 MHz Upper C block license of the 700 MHz band be subject to open platform regulations that will "allow customers, device manufacturers, third-party applications developers, and others to use or develop the devices and applications of their choosing in C block networks."[15]

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[11] *See, e.g.,* T. Wu, *Wireless Network Neutrality: Cellular Carterfone on Mobile Networks* (Feb. 2007) (available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=962027); R. Frieden, NEW AMERICA WORKING PAPER NO. 20, *Wireless Carterfone, A Long Overdue Policy Promoting Consumer Choice And Competition* (Jan. 2008) (available at: http://www.newamerica.net/files/Wireless_Carterfone_Frieden.pdf); Petition of Skype Communications S.A.R.L. to Confirm a Consumer's Right to Use Internet Communications Software and Attach Devices to Wireless Networks, RM-11361, filed February 20, 2007 ("Skype Petition"); Testimony of Ben Scott, Policy Director—the Free Press, before United States Senate Committee on Commerce, Science and Transportation (Apr. 24, 2007)(available at: http://commerce.senate.gov/public/_files/UPDATEDTESTIMONYScottCommerceTestimony424.pdf) ("Scott Testimony"); *but c.f.,* G. S. Ford, T. M. Koutsky and L. J. Spiwak, *Wireless Net Neutrality: From Carterfone to Cable Boxes*, PHOENIX CENTER POLICY BULLETIN NO. 17 (April 2007) (http://www.phoenix-center.org/PolicyBulletin/PCPB17Final.pdf).

[12] *In re Use of the Carterfone Device in Message Toll Telephone Service*, 13 FCC 2d 420 (1968) , 14 FCC 2d 571 (1968) (hereinafter *"Carterfone"*); *see also Hush-A-Phone Corp. v. American Tel. & Tel. Co.,* 20 FCC 391 (1955), *rev'd, Hush-A-Phone Corp. v. U.S.,* 238 F.2d 266 (D.C. Cir. 1956) (*per curiam), on remand, Hush-A-Phone Corp. v. American Tel. & Tel. Co.,* 22 FCC 112 (1957); 47 U.S.C. § 549; *Implementation of Section 304 of the Telecommunications Act of 1996, Commercial Availability of Navigation Devices,* 13 FCC Rcd 14775, 14775, ¶1 (1998) (*Navigation Devices Order*), *aff'd, General Instrument Corp. v. FCC,* 213 F.3d 724 (D.C. Cir. 2000). The FCC extended the implementation deadline of these requirements in 2003 *Implementation of Section 304 of the Telecommunications Act of 1996, Commercial Availability of Navigation Devices,* 18 FCC Rcd 7924 (2003), and again in 2005, *Implementation of Section 304 of the Telecommunications Act of 1996, Commercial Availability of Navigation Devices,*20 FCC Rcd 6794 (2005), *aff'd Charter Communications, Inc. v. FCC,* No. 05-1237, slip op. (D.C. Cir. Aug. 18, 2006) (available at: http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-267179A1.pdf).

[13] Wu, *supra* n. 11.

[14] Frieden, *supra* n. 11.

[15] *700 MHz Second Report and Order, supra* n. 5, at ¶ 206.

These rules prohibit Upper C block licensees from "locking" handsets that use this spectrum and state that licensees cannot "disable features or functionality in handsets" such as Wi-Fi access or MP3 ringtone capability.[16] In addition, the FCC prohibited Upper C block licensees from certain potential revenue streams, noting specifically that an Upper C block licensee "may not impose any additional discriminatory charges (one-time or recurring) or conditions on customers who seek to use devices or applications outside of those provided by the licensee."[17] The FCC noted that instead of permitting a Upper C block licensee to charge for additional bandwidth caused by particular applications, it expects that the Upper C block licensee will upgrade its facilities or use "technology-neutral capacity pricing" that does not make any distinction based upon the application being used.[18] As we recently observed in PHOENIX CENTER POLICY PAPER NO. 32, this general approach to network capacity issues can be decidedly less efficient than application-specific traffic management tools.[19] As a result, the wireless *Carterfone* mandates on the Upper C block can be expected to have a substantial impact upon the business plan for offering commercial wireless services over this spectrum.

The following table shows the band plan for the blocks of commercial spectrum that the FCC decided to auction in Auction 73. It is clear from this chart that the Upper C block represents a substantial portion of the spectrum to be auctioned.

Table 1. Auction 73 Band Plan

Block	Frequencies	Bandwidth	Pairing	Area Type	Licenses
Lower A	698-704, 728-734	12 MHz	2 x 6 MHz	EA	176
Lower B	704-710, 734-740	12 MHz	2 x 6 MHz	CMA	734
Lower E	722-728	6 MHz	unpaired	EA	176
Upper C	746-757, 776-787	22 MHz	2 x 11 MHz	REA	12
Upper D	758-763, 788-793	10 MHz	2 x 5 MHz	Nationwide	1

The disparate treatment of the Upper C block provides an opportunity to quantify, to some degree, the benefits and costs of net neutrality regulations in the wireless context. Specifically,

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[16] *Id.* at ¶ 222. The FCC noted: "Specifically, a C block licensee may not block, degrade, or interfere with the ability of end users to download and utilize applications of their choosing on the licensee's C block network, subject to reasonable network management." *Id.* at ¶ 206.

[17] *Id.* at ¶ 222.

[18] *Id.*

[19] G. S. Ford, T. M. Koutsky and L. J. Spiwak, *The Welfare Impacts of Broadband Network Management: Can Broadband Service Providers be Trusted?*, PHOENIX CENTER POLICY PAPER NO. 32 (March 2008) (available at: http://www.phoenix-center.org/pcpp/PCPP32Final.pdf).

we can utilize auction bids to analyze whether open platform or "wireless *Carterfone*" requirements have an adverse impact upon the perceived profitability of operating a commercial mobile wireless network. Using auction bids is an appropriate method of analyzing this question because the prices firms are willing to pay for disparate slices of spectrum are largely driven by the business case for offering services over that spectrum, given the various mandates and regulations attached to that license. In this case, we have a very clear and stark open platform mandate on Upper C block licenses in Auction 73 that differs considerably from the other commercial mobile licenses that the FCC has auctioned. As a result, if those open platform regulations have a substantial and measurable impact upon the business case for operating a mobile wireless network, then we should be able to see and quantify that business case impact by examining winning spectrum auction bids.

Bidders in a spectrum auction are essentially placing bids on the right to provide a wireless service—and they will base those bids upon the expected profitability of the service they can provide. Calculating how much to bid and for which license is an intensely complex and ever-changing quantitative problem, but the question bidders constantly ask themselves is a simple one: will the profit I make from offering this service in this area be larger than the bid I am about to place? In the end, auction bids are general statements by firms as to their beliefs about the future profitability of offering wireless services over spectrum that is being auctioned.

A simple economic model demonstrates this point. Say the government intends to sell by auction asset S which is essential to the provision of some service. There are two firms interested in the asset: Firm 1 and Firm 2. The expected flow of profits from the use of the asset is D and common to both firms. Entry costs, required to use S to provide a service, are E_1 and E_2, where $E_2 > E_1$ so the Firm 1 is more efficient than Firm 2. For simplicity, we assume that all values are known by both bidders.[20] The maximum bids for Firm 1 and 2 are $(D - E_1)$ and $(D - E_2)$, respectively. In a second price auction, Firm 1 wins the auction by bidding slightly higher than $(D - E_2)$ and earns an efficiency rent of approximately $E_2 - E_1$. An acknowledged (and possibly intended) consequence of open platform mandates is reduced profitability for wireless providers.[21] Limiting, by regulation, the profitability of the services sold using the asset to some known level R, where $R < D$, the winning bid becomes $R - E_2$. Assuming $R - E_2$ is positive, the difference between the unregulated and regulated services bid is $(D - R)$, which is simply the expected reduction in profits due to regulation. The percentage discount for asset S is $(R - E)/(D - E) - 1$ (ignoring the subscript) assuming all values are known. We can

[20] A thorough treatment of auction theory is provided by V. Krishna, AUCTION THEORY (2002). For a discussion of the application of theory to real-world auctions, including spectrum auctions, *see* P. Milgrom, PUTTING AUCTION THEORY TO WORK (2004).

[21] As we noted above, the FCC recognized this possibility. *See supra* n. 6 and accompanying text.

approximate the percentage reduction in profitability $[(D-R)/D]$ by multiplying the auction revenue discount by the ratio $B/(E+B)$, where B is the winning bid.

The 700 MHz auction presents an interesting and unique opportunity to study the impact that regulation would have upon profitability. As noted above, in the fourteen years that the FCC has performed spectrum auctions, never before has the FCC simultaneously auctioned similar spectrum licenses that are subject to two radically different regulatory regimes. In the following Section, we use this opportunity and the available data to quantify what we can about the open platform regulatory requirements and discover that these requirements will likely decrease the profitability of commercial uses of the Upper C block spectrum by about one third.

III. Revenue Estimation Model

In this Section, we outline our statistical analysis and show that subjecting the Upper C block spectrum to these open platform regulations has decreased the projected profitability of operating wireless broadband networks over this spectrum by 32%. We generate this estimate by examining the winning bids for two significant spectrum auctions—the recently-completed 700 MHz auction and the Advanced Wireless Services Auction 66 (AWS-1) that was completed in 2006. We use the winning bids in these auctions to predict a winning bid estimate for the Upper C block licenses. The estimate our model makes is principally based upon geographic market size of the license in terms of population, the bandwidth of the block in MHz, and the geographic scope of the license (*i.e.*, Economic Area, Cellular Market Area, or Regional Economic Area). As discussed below, these factors largely explain the differences in the winning bids for the A and B blocks of the 700 MHz band and the AWS-1 band, with 98% of the variation in winning bids explained. But when we compare these results to the winning bids for the 700 MHz Upper C block, we find that these licenses sold for 40% less than our model would predict. Because the 700 MHz Upper C block is the only block in these two auctions that was subject to open platform requirements, we can postulate that the lower price is a direct result of those regulatory requirements.[22]

A. *Data*

Our auction revenue predication model analyzes the winning bids for the A, B and C licenses in 700 MHz auction (Auction 73) and the AWS-1 auction (Auction 66), which were auctioned in 2006 and for which the FCC said is "likely to be used for similar services" as the

[22] Our approach may, in fact, underestimate the impact of mandated open standards since firms may have reduced their bids due to the fact the Skype's wireless *Carterfone* petition was pending before the FCC at the time of the auction. Petition of Skype Communications S.A.R.L. to Confirm a Consumer's Right to Use Internet Communications Software and Attach Devices to Wireless Networks, FCC RM-11361 (filed Feb. 20, 2007).

700 MHz licenses.[23] For our regression analysis, the Lower A, Lower B, Upper C and Lower E blocks are relevant and analyzed. The Upper D block is excluded and as it is generally not comparable to the A, B, C and E blocks for obvious reasons. In particular, the D block is a 10 MHz nationwide license principally for public safety purposes that requires the winning commercial bidder to build a wireless network principally for use by first-responders like police and fire squads. More importantly, the reserve price for the D block was not met in the auction, so there is no final winning bid to use in our model.[24] The FCC web site provides all of the analysis data, including winning bids, population, and bandwidth information for the auctions that we analyze, Auctions 66 and 73.[25]

For every spectrum auction, the FCC makes two critical decisions that affect the value of the spectrum to be auctioned—the license size (the amount of spectrum for each license, measured in Hertz, such as 10 MHz and 22 MHz sized blocks) and the geographic area of each license. The FCC has a policy of establishing bands that have a mixture of different spectrum size and geographic areas.[26] Both the AWS-1 and 700 MHz auctions that we study consisted of spectrum in three different geographic areas, the Cellular market Area ("CMA"), the Economic Area ("BEA" or "EA") and the Regional Economic Area ("REA"). Because the Upper C block that we are interested in studying was auctioned on an REA basis, we aggregate the winning bids from A, B, and C blocks from AWS-1 and the A and B blocks from 700 MHz into REAs. We limit our attention to the six REAs of the contiguous United States and the two for Alaska and Hawaii (8 total).[27] Tables A-1 and A-2 in the Appendix provides a summary of the data.

In the end, aggregating in this matter gives us 10 blocks over 8 REAs, for a total sample size of 80 observations (48 from Auction 66 and 32 from Auction 73). Importantly, four of the ten blocks in the sample are native REA-level auctions. As discussed above, only the Upper C block licenses in Auction 73 are subject to these wireless *Carterfone* rules. All of the other blocks we study are not subject to any comparable restriction or regulation.

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[23] *700 MHz Second Report and Order, supra* n. 5, at ¶ 64.

[24] It could be argued that the Lower E block is likewise sufficiently different from the others to warrant exclusion. The Lower E block is a small, unpaired 6 MHz slice of spectrum (722-728 MHz) that, according to the FCC, is likely to be only of use when combined with adjacent spectrum or when used to provide one-way "broadcast-type" operations. *Id.* at ¶¶87-88. However, the econometric results and, consequently, our conclusions are not much affected by the inclusion or exclusion of the Lower E block, so we include it in the sample.

[25] *See* http://wireless.fcc.gov/auctions/default.htm?job=auctions_all.

[26] *700 MHz Second Report and Order, supra* n. 5, at ¶ 62.

[27] Excluded REAs include "Guam, Northern Mariana Islands" and "Puerto Rico, US Virgin Islands."

B. *Estimation and Results*

To estimate size of the devaluation of the C block in Auction 73 due to the open access requirements, we predict the auction prices for the C block licenses using an econometric model. The price in REA *i*, block *b*, is modeled as

$$\ln P_{i,b} = \beta_0 + \beta_1 \ln POP_{i,b} + \beta_2 \ln MHZ_{i,b} + \beta_3 DREA_{i,b} + \beta_4 AUC73_{i,b} + \beta_4 BB73_{i,b} + e_{i,b} \qquad (1)$$

where "ln" indicates the natural logarithmic transformation, *DREA* is a dummy variable equal to 1 for all spectrum auctioned at the REA level, *AUC73* is a dummy variable for all licenses sold in Auction 73, *BB73* is a dummy variable for the B block in Auction 73, and *e* is the disturbance term. Equation (1) is estimated by Ordinary Least Squares ("OLS"). In Equation (1), we assume the winning auction bids are primarily a function of the size of the market in population (*POP*) and the size of the block in megahertz (*MHZ*).

We include a dummy variable for the 12 MHz B block in Auction 73 (*BB73*) because the block is located adjacent to another 12 MHz block in the 700 MHz band auctioned earlier by the FCC. Consequently, the bids for that block may be larger due to due the fact joining the two blocks makes a 24 Mhz block. The B block auction is effectively a 24 MHz block for some participants—those with the license for the adjacent 12 MHz block, those who believe they can acquire access to it, or those seeking deals with either of these two—and this higher value should be reflected in prices. Indeed, AT&T, a company that holds licenses in the adjacent 12 MHz block, offered the highest bids for a large share of the B block licenses in Auction 73. We employ two approaches to deal with this situation. First, we simply include a dummy variable for the B block. Second, we alter the data so that the B block is a 24 MHz block (increasing it from 12 MHz). If we estimate the regression with both corrections, then whether or not the price difference is based on joining the two 12 MHz blocks is testable by the statistical significance of the B block dummy variable. We also include a regression where the prices for the adjoining 12 MHz band from Auction 44 are included in the prices for the B block, though bidders at the time did not necessarily know that the adjacent spectrum would be available to them in the future and many of the licenses have been sold since the initial auction.

Equation (1) is estimated using all the data except for the C block of Auction 73. Based on the estimated parameters, we can predict the value of the C block in the absence of the open access regulations. The predicted value for any license at the REA level is simply

$$\ln \hat{P} = \hat{\beta} X \qquad (2)$$

where the caret "^" indicates a predicted value and *X* is the vector of regressors relevant to the Upper C block of Auction 73. The discount at the REA level is simply $P_i - \hat{P}_i$, with a percentage

reduction of $(P_i - \hat{P}_i) / \hat{P}_i$. Summing across all m markets, the aggregate magnitude of the discount in dollars is simply

$$\text{Discount} = \sum_{i=1}^{m} P_i - \sum_{i=1}^{m} \hat{P}_i \,. \tag{3}$$

This value is conceptually equal to $(D - R)$ from above (under simplifying assumptions). Since the Upper C block is the only 22 MHz block in the sample, an Upper C block dummy variable is collinear with the MHZ variable. Consequently, a "forecast" approach seems most sensible and is the only practical option.

C. *Estimates*

Equation (1) is estimated using 72 observations, and the results are summarized in Table 2. Model 1 is the most basic of the specifications. All of the included variables are statistically significant at the 5% level or better (based on White's robust t-statistics), and the regression explains 98% of the variability in (the natural log of) price. This fit is exceptional given the small sample size and cross section nature of the data. Estimated parameters for Equation (1) indicate that for a 10% increase in the size of the market (in population), price rises by about 13% (based on β_1 ˜ 1.32). We can reject unit elasticity of price with respect to population (since the hypothesis $\beta_1 = 1$ is easily rejected with an F-Statistic of 164.7). Alternately, we cannot reject unit elasticity for block size since the hypothesis that $\beta_2 = 1$ is not rejected at traditional significance levels (β_2 ˜ 1.15; F-Statistic = 1.11). In common parlance, these results suggest it is reasonable to assume that twice the block size brings roughly twice the price, but twice the market size brings more than twice the price. These results suggests that the common measure of auction price of Price/MHz/Pop (price per megahertz per population), or some variation of it, is biased at anything but the national level since prices are not proportional to population.

Table 2. Regression Results

	Model 1	Model 2	Model 3	Model 4	Mean [St. Dev.]
Constant	-6.874 (-11.22)*	-6.874 (-11.21)*	-7.106 (-14.27)*	-7.118 (-14.27)*	…
ln*POP*	1.320 (52.96)*	1.320 (52.96)*	1.320 (52.74)*	1.320 (52.75)*	16.65 [1.74]
ln*MHZ*	1.15 (7.89)*	1.154 (7.89)*	1.238 (11.51)*	1.245 (11.57)*	2.52 [0.39]
DREA	0.271 (2.36)*	0.270 (2.36)*	0.290 (2.59)*	0.291 (2.60)*	0.33 […]
AUC73	0.715 (4.64)*	0.715 (4.64)*	0.803 (7.43)*	0.810 (7.49)*	0.33 […]
BB73	0.993 (6.31)*	0.193 (0.92)	…	…	0.11 […]
R^2	0.98	0.98	0.98	0.98	…
F-Stat	582.2*	581.6*	729.0*	728.8*	…
Obs.	72	72	72	72	72

Robust t-statistics in parenthesis.
* Statistically significant at the 5% level or better.

We also see support for the hypothesis that the whole is more valuable than the sum of its parts. Spectrum licenses auctioned at the REA level brings roughly a 31% premium on average [exp(0.27) – 1 = 0.31] for these two auctions. The other dummy variables indicate both economically and statistically significant effects. Licenses in Auction 73 sold, on average, for about a 105% premium over the AWS licenses [exp(0.72) – 1 = 1.05]. The B block in Auction 73 sold at a 169% premium [exp(0.99) – 1 = 1.69] over the A block, confirming that the adjacency to another 12 MHz block strongly influenced bidding on the B block.

If we adjust the MHz data for the Auction 73 B block to 24 MHz (Model 2), then we find that the *BB73* dummy variable is no longer statistically different from zero. Note also that the coefficients of the regression are essentially unchanged. These results suggest that the prices for the B block are largely based on the ability to combine the two 12 MHz blocks into a single 24 MHz block. Unsurprisingly, excluding the *BB73* regressor from Model 2 does not materially impact the results in Model 3. Finally, in Model 4, we include in the final bids for the Auction 73 B block the final bids for the adjacent 12 MHz block from Auction 44, treating the licenses as 24 MHz blocks and including all prices paid for the licenses. This final specification is a stretch since the Auction 73 band plan was not known at the time the earlier bids were

made and licenses have been sold, but some readers may be interested in the results. We do not discuss the results for Model 4 further.

D. *Impact of Wireless Carterfone Regulation on the Value of Spectrum*

We turn now to the question of quantifying the price reduction for the Upper C block license in Auction 73. Inserting the relevant values of the regressors for the Upper C block into the estimates from Equation (1), we predict the Upper C block should have sold for approximately $7.9 billion based on the calculations in Equations (2) and (3). The actual price for the block was about $4.75 billion, which suggests that the open access regulations trimmed $3.1 billion from the winning bids, or nearly a 40% loss in revenues. These calculations imply that because of the open platform mandate, the Upper C block licenses were nearly 40% less valuable than they would have been if those regulations had not been in place.

The results using Model 2 generate almost identical results. Models 3 and 4 forecast even greater devaluation of the Upper C block licenses, as they predict than an unencumbered Upper C block licenses would have fetched about $9 billion, so the cost of the open platform mandate in terms of lost auction revenue rises to just over $4 billion. In those two cases, the open platform regulations have had the effect of devaluing the Upper C block licenses by about 48%. To be conservative, our discussion is based mainly on the lowest estimate of the reduction in auction revenues of $3.1 billion (or 40%). Further, this estimate is based on what we believe to be the most reasonable specification of the model.

E. *Impact of Open Platform Regulations on Industry Structure*

Using the discount on auction revenues for the C block, we can infer the reduction in profitability for the incremental services sold using that spectrum using the formula provided above. Estimates of the cost of deploying a 700 MHz network vary widely, but one of the few independent estimates placed the incremental network cost at about $2 billion.[28] Some estimates of a so-called "greenfield" build-out were closer to $10-12 billion, but most of the auction bidders were not newcomers to the wireless industry and therefore would be able to

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[28] J. Mansell, *Regulation, Public Policy and Spectrum Rights Acquisition, Surveying Options for New North American Spectrum Acquisition and Valuation*, Presentation at the Wireless Communications Association (Jun. 28, 2006); B. Gardiner, *FAQ: Inside the High-Stakes 700-MHz Spectrum Auction*, WIRED MAGAZINE (Jan. 24, 2008); Declaration of Dr. Stagg Newman, attached to Comments of Access Spectrum, L.L.C., Columbia Capital III, LLC, Pegasus Communications Corporation and Telcom Ventures, LLC, WT Docket Nos. 06-150 and 01-309 and CC Docket No. 94-102, ¶ 1 (Sep. 29, 2006).

deploy services that utilize existing infrastructure like towers and back-office assets.[29] Assuming that the incremental, non-spectrum investments to provide service using 700 MHz spectrum are $2 billion, the discount on the Upper C block spectrum suggests that the wireless *Carterfone* regulations reduce the profitability of providing incremental services over that spectrum by 32%.[30]

Applied broadly to all commercial mobile spectrum, wireless *Carterfone* mandates should be expected to reduce profitability for all providers in a similar manner. Indeed, the 32% reduction we can infer from the 700 MHz auction may be on the low end, because Verizon may be able to allocate its service offerings across its other spectrum holdings in order to minimize the profit impact of the open platform regulations. If applied to all spectrum, then the profit impact of open platform mandate would be more difficult to avoid. Such a sizeable reduction in the profitability of wireless services should of course be expected to have important financial implications for carriers as well as service and price consequences for consumers.

Given the presence of large fixed and sunk costs in the wireless industry, a substantial reduction in profitability is likely to impact market structure. While bidders on the Upper C block were able to adjust their bids to take into account the financial impact of the new wireless *Carterfone* regulations,[31] holders of unencumbered licenses do not necessarily have that opportunity and may need to write down the value of certain assets.

In addition, because future profits would be reduced by such regulation, one should expect that future investments by wireless providers would be curtailed. A 32% reduction of profitability due to wireless *Carterfone* regulation could be expected to reduce investments in wireless infrastructure by about $50 billion over the next 10 years, though for reasons stated above, this is likely an underestimate. We base this estimate using an elasticity of investment

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[29] *See* R. Mark, *Google Network Could Cost Almost $17 Billion to Build*, EWEEK (Sep. 26, 2007) (available at: http://www.eweek.com/c/a/Mobile-and-Wireless/Google-Network-Could-Cost-Almost-17-Billion-to-Build/) (noting network construction costs of $12 billion and $4.6 billion to acquire spectrum).

[30] The spectrum revenue discount is 0.40 and the spectrum's share of total investment is 7.9/(7.9 + 2) = 0.80. Based on the formula from earlier in the text, the discounted profitability on incremental services is 0.40·0.80 = 0.32.

[31] Verizon's return on investment is not reduced due to the open network mandate on the C block, since the price of C block was discounted to reflect the lower flow of profits from services. For example, say the normal return is 10%. The expected flow of gross profits from services is $100 and network costs are $25. If the necessary spectrum asset is sold at auction, the value of the spectrum is about $66 [(100 – 25 – 66)/(25 + 66) = 0.10]. If regulation reduces the flow of profits to $60, then the spectrum asset is valued only at about $30. If a firm has already made the investments of $25 and $66 in an unregulated setting only to be subsequently regulated, the financial difficulties it faces are apparent.

with respect to profit of 1.0, a figure we generate by reference to the last five years of financial reports for Verizon and AT&T.[32]

Calculating the impact of broadly applied regulation is complex. But it seems sensible to presume a one-third reduction in the profitability of providing service would make firms less interested in entering or remaining in the market, due to the need to cover the substantial up-front and continuing investments in wireless infrastructure.[33] While it is difficult, ex ante, to predict the exact distribution across asset classes of such a dramatic financial shock, from a practical perspective the reduced profitability will likely favor larger wireless firms. This is because lower profits and commoditization of service, which network neutrality mandates would foster, would certainly enhance the role of scale economies in determining market structure.[34] Evidence suggests that larger firms enjoy considerable cost advantages over their smaller counterparts, and scale economies are inherent to and significant for most telecommunications plant.[35] Consequently, the decision of whether to more broadly apply the wireless *Carterfone* regulations must involve an explicit and thorough analysis of the impact such regulation will have on smaller wireless carriers.

Admittedly, our calculations are based on a number of simplifying assumptions. But if the calculations are even roughly accurate, then the costs of mandating open platforms throughout

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[32] The relationship between investment and profits can be very complex, so we turn to some simple empirics for a rough approximation. Using the last five years of data for Verizon and AT&T, we regress the natural log of capital expenditures on the natural log of operating income (including a constant term and a dummy variable for Verizon). The coefficient on operating income is 1.04, indicating an elasticity of approximately unity. If we include a time trend, then the coefficient is 0.90, again indicating an elasticity of approximately 1.0. Aggregate wireless investment on an annual basis is about $20 billion, or $175 billion over 10 years (discounted for inflation), and $200 billion ignoring inflation. Comments of Cellular Telecommunications Industry Ass'n., WT Docket No. 08-27 (filed Mar. 26, 2007); *see also* http://www.ctia.org/advocacy/research/index.cfm/AID/10323. A 32% reduction of these amounts renders approximately a $55 to $65 billion reduction in investment.

[33] J. B. Duvall and G. S. Ford, *Changing Industry Structure: The Economics of Entry and Price Competition*, PHOENIX CENTER POLICY PAPER NO. 10 (Apr. 2001) (available at http://www.phoenix-center.org/pcpp/PCPP10Final.pdf and reprinted in 7 TELECOM. AND SPACE JOURNAL 11 (2002)). *See also* G. S. Ford, T. M. Koutsky and L. J. Spiwak, *Competition After Unbundling: Entry, Industry Structure and Convergence*, 59 FEDERAL COMMUNICATIONS LAW JOURNAL 331 (2007); T. R. Beard, G. S. Ford, T. M. Koutsky, & L. J. Spiwak, *Network Neutrality and Industry Structure*, 29 HASTINGS COMMUNICATIONS AND ENTERTAINMENT LAW JOURNAL 149 (2007); T. R. Beard, G. S. Ford and L. J. Spiwak, *Why ADCo? Why Now? An Economic Exploration into the Future Industry Structure for the "Last Mile" in Local Telecommunications Markets*, 54 FED. COM. L. J. 421 (May 2002); J. Sutton, SUNK COST AND MARKET STRUCTURE (1995).

[34] *See* Beard *et al.*, *Network Neutrality and Industry Structure*, *supra* n. 33.

[35] *See, e.g.*, T. R. Beard, G. S. Ford and R. Saba, *An Econometric-Driven Merger Simulation: Considerations and Application*, 13 INT'L J. ECON. BUSINESS 217 (2006). Of course, spectrum licenses are paid for in lump sum payments making spectrum a contributor to scale economies.

the industry are potentially very large. Clearly, the large discount on the C block predicts a substantial shock to industry structure if open platform mandates were applied broadly in the wireless industry. Moreover, shrinking the potential market and commoditizing wireless services as a result of an open platform mandate can be expected to place pressure upon small and medium-sized broadband wireless firms. Such across-the-board requirements may even cause many small or mid-sized broadband wireless firms to exit the market entirely. At a minimum, these estimates of the costs of such a mandate necessitate that the alleged benefits of openness be calculated, so that a proper cost-benefit analysis of the regulations can be undertaken.

IV. Conclusion

In the last year, the practices of wireless companies with regard to locking some handsets and offering exclusive content, applications and bundling discounted handsets with service plans have come under attack. Many advocates have called for new regulations that would effectively mandate the technical configuration and operation of wireless networks, while limiting the ability of wireless firms to monetize their investment in spectrum and network infrastructure. The FCC partially heeded this call when it imposed wireless *Carterfone* regulations on one substantial block of spectrum (the Upper C block of the 700 MHz band) that was recently put up for bid in a record-setting auction.

In this BULLETIN, we utilize the results of that auction to show that the regulatory mandates imposed by the FCC will decrease the profitability of wireless network services that utilize those licenses by 32%. This impact is clearly reflected in the lesser amounts bid for the encumbered spectrum. We find that if the FCC had not imposed these open platform regulations on the Upper C block, then U.S. taxpayers likely would have collected an additional $3.1 billion from the auction of those licenses.

But the impact on profitability of these mandates has important policy implications that go well beyond reduced auction revenues. The auction results indicate that the return on investment into a regulated "open platform" is lower, and we estimate that imposing wireless *Carterfone* regulations generally could cause a $50 billion decrease in wireless network investment over the next ten years. If imposed broadly, wireless *Carterfone* regulations also could have a sizeable impact upon market structure and create a significant risk that firms may exit the wireless market. Moreover, these pressures are likely to strike small and medium-sized broadband wireless providers the most, given the scale economies that are endemic to the wireless industry.

Given these findings, policymakers should take great care in considering whether to extend *Carterfone* and similar regulatory mandates to spectrum beyond the 700 MHz Upper C block. We have discussed before that this type of regulation should be subject to a cost/benefit analysis that balances the costs of regulation against the consumer and social welfare benefits.

It has been claimed that more regulation can generate substantial benefits from a more innovative and competitive "upstream" market for handsets and wireless applications from wireless *Carterfone* policies. These potential benefits may exist, although we have not seen any positive or even semi-rigorous analysis that attempts to quantify those benefits in the upstream market. But our analysis does show that broad application of wireless *Carterfone* regulation could cause a significant drop in wireless infrastructure investment and sharp reduction in the profitability of offering commercial wireless services, to the point that some firms may be driven from the market. Given this enormous potential impact such a development would have upon consumer choice, some quantification of the benefits of these proposed regulations seems necessary.

Second Edition:

Table 2 and the tables in the Appendix have been updated. The original tables were not based on the final dataset used to compute the discount. Only the tables and associated text (Section III.C) have changed, and the changes are insignificant. The estimates of the discount and its implications are unaffected.

Appendix A

Table A-1. Auction 73 Data

REA	AUCTION	BLOCK	MHZ	PRICE
REA001	73	A	12	$1,003,917,000
REA002	73	A	12	$607,795,000
REA003	73	A	12	$507,758,000
REA004	73	A	12	$378,938,000
REA005	73	A	12	$442,877,000
REA006	73	A	12	$992,858,000
REA007	73	A	12	$1,315,000
REA008	73	A	12	$3,728,000
REA001	73	B	12	$2,025,815,753
REA002	73	B	12	$1,635,080,961
REA003	73	B	12	$2,046,102,915
REA004	73	B	12	$657,270,501
REA005	73	B	12	$1,032,207,287
REA006	73	B	12	$1,716,048,584
REA007	73	B	12	$2,182,000
REA008	73	B	12	$13,118,000
REA001	73	C	22	$502,774,000
REA002	73	C	22	$424,224,000
REA003	73	C	22	$1,109,715,000
REA004	73	C	22	$1,625,930,000
REA005	73	C	22	$723,228,000
REA006	73	C	22	$319,798,000
REA007	73	C	22	$1,783,000
REA008	73	C	22	$36,138,000
REA001	73	E	6	$324,299,000
REA002	73	E	6	$203,580,000
REA003	73	E	6	$173,064,000
REA004	73	E	6	$63,999,000
REA005	73	E	6	$159,481,000
REA006	73	E	6	$329,904,000
REA007	73	E	6	$1,002,000
REA008	73	E	6	$1,088,000

Table A-2. Auction AWS-1 Data

REA	AUCTION	BLOCK	MHZ	PRICE
REA001	AWS-1	A	20	$621,430,030
REA002	AWS-1	A	20	$422,804,380
REA003	AWS-1	A	20	$501,389,311
REA004	AWS-1	A	20	$146,230,875
REA005	AWS-1	A	20	$201,890,566
REA006	AWS-1	A	20	$344,844,638
REA007	AWS-1	A	20	$1,770,750
REA008	AWS-1	A	20	$3,733,750
REA001	AWS-1	B	20	$646,944,000
REA002	AWS-1	B	20	$431,211,000
REA003	AWS-1	B	20	$501,695,500
REA004	AWS-1	B	20	$166,265,250
REA005	AWS-1	B	20	$258,235,500
REA006	AWS-1	B	20	$426,678,500
REA007	AWS-1	B	20	$1,809,000
REA008	AWS-1	B	20	$4,254,000
REA001	AWS-1	C	10	$468,904,750
REA002	AWS-1	C	10	$225,437,250
REA003	AWS-1	C	10	$327,929,450
REA004	AWS-1	C	10	$92,438,000
REA005	AWS-1	C	10	$129,355,650
REA006	AWS-1	C	10	$211,879,500
REA007	AWS-1	C	10	$1,111,000
REA008	AWS-1	C	10	$2,440,000
REA001	AWS-1	D	10	$552,694,000
REA002	AWS-1	D	10	$236,549,000
REA003	AWS-1	D	10	$274,083,750
REA004	AWS-1	D	10	$110,586,000
REA005	AWS-1	D	10	$134,954,000
REA006	AWS-1	D	10	$355,726,000
REA007	AWS-1	D	10	$1,096,000
REA008	AWS-1	D	10	$1,433,000
REA001	AWS-1	E	10	$472,553,000
REA002	AWS-1	E	10	$310,995,000
REA003	AWS-1	E	10	$356,780,000
REA004	AWS-1	E	10	$79,376,250
REA005	AWS-1	E	10	$122,284,000
REA006	AWS-1	E	10	$362,757,000
REA007	AWS-1	E	10	$1,098,000
REA008	AWS-1	E	10	$1,919,000
REA001	AWS-1	F	20	$1,335,374,000
REA002	AWS-1	F	20	$572,446,000
REA003	AWS-1	F	20	$615,923,000
REA004	AWS-1	F	20	$274,995,000
REA005	AWS-1	F	20	$470,290,000
REA006	AWS-1	F	20	$894,590,000
REA007	AWS-1	F	20	$1,187,000
REA008	AWS-1	F	20	$6,107,000

PHOENIX CENTER FOR ADVANCED LEGAL & ECONOMIC PUBLIC POLICY STUDIES
5335 Wisconsin Avenue, NW, Suite 440
Washington, D.C. 20015
Tel: (+1) (202) 274-0235 ? Fax: (+1) (202) 318-4909
www.phoenix-center.org