PERSPECTIVES

PHOENIX CENTER FOR ADVANCED LEGAL & ECONOMIC PUBLIC POLICY STUDIES

Expediting Spectrum Repurposing Through Market Transactions

Dr. T. Randolph Beard
Dr. George S. Ford*

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The exponential growth in mobile broadband data consumption continues unimpeded, stretching the electromagnetic radio spectrum resource required to support that data flow to its limits.[1] While there is broad consensus that much more spectrum for commercial mobile wireless data service is needed, almost all of the resource is already allocated and assigned to uses and users meaning, in turn, that what spectrum is given to mobile wireless services and carriers must be taken from others. Repurposing the Federal Government's vast holdings of spectrum is one source of potential inventory,[2] and private actors in search of immediate solutions are shuffling licenses among themselves in market transactions in an attempt to repurpose spectrum to higher valued uses.[3]

Government processes are, by nature if not by design, deliberate and prone to special interest lagniappe, so spectrum repurposing is often excruciating slow.[4] While spectrum auctions are the favored mechanism of rights assignment, identifying spectrum, clearing it, and getting it on the auction block takes, on average, a decade or more.[5] Such delays are socially costly because, as the reassignment process slowly progresses, the spectrum remains either unused or else applied to low-value services.

An alternative approach is for the Commission to encourage, or continue to encourage, market-based solutions whereby parties negotiate directly among themselves to repurpose spectrum, an approach the Commission appears to be contemplating for the 900 MHz band (among others). Yet, while voluntary commercial negotiations are desirable, there is nonetheless a risk of "holdups" where sellers delay making an agreement in order to unmask the private information of the buyer and, thereby, earn higher profits from the sale of licenses. As explained below, such delays, while privately profitable, are not socially innocuous because they postpone the repurposing of the spectrum to a higher-valued use and thus destroy value. These losses from delay are a pure, unrecoverable loss to society—losses that are often incremental to those already realized from the lengthy repurposing process prior to such permitted dealings.

In this PERSPECTIVE, we present an economic model of how to design sensibly a market-based repurposing using the concept of an expiring "transaction window." Specifically, we consider a two-stage process whereby incumbent licensees are first granted a fixed period of time to sell, acquire, or repurpose their licenses (i.e., the transaction window). To ensure an expeditious repurposing, this transaction window expires at a known, fixed date, at which time licenses held by incumbents that are not participating in or eligible for providing the "new" service are, in effect, reclaimed, and these incumbents are provided compensation established by the Commission. For instance, consistent with historical practice, incumbents might be relocated, perhaps at the expense of the new licensees, to new spectrum bands where

a functionally equivalent flow of services may be obtained.[6] These reclaimed licenses are then assigned (through some unspecified mechanism) to those licensees in the band eligible for and interested in providing the services for which the spectrum is being repurposed.

Background

As a general principle, property is most efficiently allocated through market transactions.[7] The simplest economic motive—profit maximization—usually provides buyers and sellers with the proper incentives to see that property is allocated to its most valuable uses. The benefits of market transactions for spectrum allocation are now recognized, and the U.S. Congress and FCC have fully embraced spectrum auctions, as have the legislatures and regulators of many other nations.[8] As observed by the FCC, the purpose of the spectrum auction "is to harness the economics of demand for spectrum in order to allow market forces to determine its highest and best use."[9] In authorizing spectrum auctions in the *Omnibus Budget Reconciliation Act of 1993*, Congress directed the Commission to design auctions to ensure the "efficient and intensive use of electromagnetic spectrum."[10]

A spectrum auction is not the only way to allow market forces to determine the highest and best use of spectrum, however. Direct market transactions for flexible licenses are also well-suited to repurposing spectrum to new users and uses, and such commonplace private mechanisms are generally much more efficient than government processes. For example, in 2012, in a process that took a little over one-year, DISH Networks repurposed 40 MHz of satellite spectrum to terrestrial applications, a relatively large transfer of mostly idle spectrum to higher-valued uses and a favorable outcome by nearly any standard.[11] This relatively rapid repurposing did not involve incumbent licensees, however, as DISH had acquired the entirety of the spectrum in a bankruptcy proceeding.

With many incumbent licensees, some of whom actively use the spectrum to provide some sort of service, repurposing is more problematic. In years past, the Commission has repurposed huge swaths of spectrum already assigned and used, moving interested incumbents to other bands (with minimal business interruption) where the flow of services they enjoyed could be efficiently replicated. The recent $40 billion Auction 97 proceeding is one instance of such an arrangement.[12] Still, this process is often protracted, forcing society to forego the substantial benefits available from a more-timely repurposing.

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Another interesting example relevant to this analysis is the attempt to expedite the repurposing of portions of the 900 MHz band used at present for the internal, narrowband communications needs of incumbent licenses (e.g., utilities). The Enterprise Wireless Alliance and PDV Wireless have proposed that the Commission permit incumbent licensees to sell their licenses to interested parties, including other incumbent license holders, in an effort to obtain a sufficient amount of spectrum (a paired 3x3 MHz block) to operate a broadband network.[13] This broadband block is referred to

as the Private Enterprise Broadband ("PEBB") licenses.

A two-stage process is contemplated in this PEBB proposal, wherein the applicants are first allowed to acquire licenses held in inventory, and to buy, sell or trade licenses among licensees. Recognizing the potential for protracted bargaining and delay, a second stage is also proposed during which, as is standard, incumbents are moved to new bands and receive some level of compensation for doing so.

In this second stage, incumbent licensees would be relocated to other portions of the band, their equipment would be re-tuned at the expense of the new broadband licensee, and the former licensees would realize no loss in their legacy services (in fact, several parties in the 900 MHz band have already done so). Such mandatory negotiations and relocations have occurred before, such as those that repurposed spectrum used for Fixed Microwave Services to Personal Communications Services ("PCS") and Advanced Wireless Services ("AWS").[14] The broadcast Incentive Auction is also a classic example, where broadcasters who did not sell their spectrum at auction were forced to relocate.[15] How and when this second-stage auction or other assignment process would occur is unspecified. It would serve, in the context of our analysis, as a means by which to establish a level of compensation in the second period. However, a well-designed transaction window may alleviate the need to auction very many licenses and allow broadband service to be supplied in the band sooner rather than later.

Certainly, allowing for the direct sale of licenses expedites a repurposing by placating incumbents with financial compensation for their licenses (many of the industrial licenses were obtained for free). As is plain, however, the pursuit of such rewards may introduce strategic bargaining problems, including hold-outs. As Shakespeare observed—*in delay there lies no plenty*—and this is certainly true today for our attempts to increase spectrum available for broadband services.[16] How, then, can the Commission facilitate the rapid redeployment of spectrum, yet continue to facilitate incumbent cooperation with the repurposing? We turn to that question now.

Simple Bargaining Model

The basic economic problem of repurposing legacy spectrum licenses is one of aligning the social and private interests involved. In the case of the 900 MHz band, many incumbents hold licenses to spectrum which they use for relatively low-value internal communications. Those wishing to buy the licenses intend to build a broadband communication network, a presumably much more valuable purpose. Ordinarily, of course, we would expect these parties to make a transaction so that the spectrum is applied to its most high-valued use. The famous economic result known as the Coase Theorem proposes that the most beneficial uses of property will be obtained regardless of the initial assignment of property rights: it is in everybody's interest to see a profitable project through because, by trading at agreed prices, all may share in the gains.

The Coase Theorem, however, involves many assumptions which may not apply in "real" markets, and sometimes the market process can benefit from some public assistance. In the case of the 900 MHz band, the current licensees cannot be expected to know the value of the spectrum licenses to potential buyers, a circumstance termed "*incomplete information*" in economics. This asymmetry in information has an immediate practical implication: since the potential seller can assure herself of higher profits by learning the value assigned to the rights by the potential buyer, the seller may take actions that increase the expected time until the spectrum is applied to the higher-valued use. Put in simple and familiar terms, the seller may "take her sweet time" in making an agreement in order to potentially unmask the private information of the buyer and, thereby, earn

higher profits for herself. This is not socially innocuous, however, because in the interim, the spectrum is not used in its highest valued use. This is a pure, unrecoverable loss to society.

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We explain this phenomenon with a simple, two-period bargaining model. Although this model, like all models, is vastly over-simplified, it illustrates well the public stakes in the repurposing process. We assume throughout this analysis the absence of any in-band or out-of-band interference concerns; that is, there are no interference externalities from the repurposing.[17]

Suppose Firm A owns a segment of spectrum for which it has a private value of V. Also, suppose another firm (Firm B) values the same piece of spectrum by $V + \theta$, where $\theta > 0$. That is, the spectrum is more valuable (by amount θ) if it is repurposed to Firm B in Period 1. To keep matters simple, assume that θ is a uniformly distributed random variable on the interval $(0, \Delta]$. While Firm B has private information about the realization of θ, Firm A only knows the distribution.

It is important to recognize what θ represents. This value is the value to Firm B on which it makes its first-period decision on Firm A's offer. This decision can incorporate all sorts of forecasts as to the likely consequences of not accepting the offer, which may or may not include B obtaining the spectrum later under some future process. This generality is desirable, but it is purchased at an analytical price: we will assume that the consequences to Firm A if B does not accept the first-round offer are independent of Firm A's first-round offer. This simplification, however, does not undermine the basic message of the analysis.

Time is divided into two periods, Period 1 and Period 2. Period 1 is a *transaction window* during which Firm A can offer to sell the spectrum to Firm B at a price P_1. Firm B can accept or reject the offer; all transactions are voluntary during the transactions window. If Firm B rejects the offer, then Firm A will hold the spectrum into the second period. Critically, Firm A expects to receive compensation of value Z in exchange for the spectrum in Period 2, and this level of compensation is established by the regulator (the FCC in this case).

The probabilities that Firm B accepts or rejects P_1, are given by:

$$\Pr[Accept] = \frac{V + \Delta - P_1}{\Delta} \qquad (1)$$

$$\Pr[Reject] = \frac{P_1 - V}{\Delta} \qquad (2)$$

Firm A will choose P_1 to maximize its expected payoff:

$$\max_{P_1}\begin{Bmatrix}(P_1 - V)\Pr[Accept] + \\ (Z - V)\Pr[Reject]\end{Bmatrix} \quad (3)$$

Substituting the Expressions (1) and (2) into (3), we have

$$\max_{P_1}\begin{Bmatrix}(P_1 - V)\dfrac{V + \Delta - P_1}{\Delta} + \\ (Z - V)\dfrac{P_1 - V}{\Delta}\end{Bmatrix} \quad (4)$$

This reduces to the equivalent optimization problem:

$$\max_{P_1}\{(P_1 - V)(Z + \Delta - V)\}. \quad (5)$$

The first-order necessary condition for the maximization of Expression (5) yields the following period one price offer:

$$P_1^* = V + \tfrac{1}{2}(\Delta + (Z - V)). \quad (6)$$

Thus, the probability of the socially beneficial transfer of spectrum in period one would be:

$$\Pr[Accept \mid P_1^*] = \frac{1}{2} + \frac{V - Z}{2\Delta}. \quad (7)$$

Notice that this probability is a decreasing function of the second period compensation Z. Thus, the Commission can increase the probability of a socially beneficial first period transaction by diminishing the future expected compensation of Firm A from retaining the spectrum into future periods.

Policy Discussion

The welfare consequences of Expression (7) are immediate and deserve emphasis. The problem modeled here involves no sunk investments (or, indeed, investments of any kind), and from the social point-of-view, the actual price at which the license is transferred from Firm A to Firm B is irrelevant. It is emphatically *not* irrelevant to Firm A, however. This has a consequence which is socially costly: Firm A can have an incentive to ask for a price in the first period that results in delayed repurposing of spectrum to its most valuable use. Of course, the degree to which this perverse incentive arises depends on the expectation which Firm A has towards its ultimate payoff if an initial price offer is not accepted. This is, largely, a matter of Commission policy.

Equation (7) provides a simple, intuitive look at the way policy and the transaction window can interact. The regulator can encourage quicker repurposing by reducing the compensation Z that Firm A would hope to earn if early sales do not occur. This, of course, is an important policy decision. What are some reasonable approaches to this question?

It is certainly plausible to select Z so that an incumbent, especially one who paid nothing for the license initially, would receive compensation sufficient to provide benefits equal to its initial use of the property. This approach probably provides relatively strong incentives for the incumbent to try to make a deal early in the process. Further, the incumbent licensee is guaranteed not to suffer compared to the pre-sale status quo. Finally, such re-location and re-tuning approach has a robust history in U.S. spectrum policy.

Although the analysis given here provides a theoretical motive to limit the time available to the incumbent to make a sale at a negotiated price, there is also considerable empirical evidence that the existence of such a "deadline" has a powerful effect on the negotiating parties. Extensive empirical evidence suggests that, in the presence of a deadline, a very high percentage of agreements will occur in the period *just before the deadline.*[18] This, in turn, suggests that, in designing a two-stage repurposing mechanism, the Commission should recognize that the actual maximum time limit they establish may well be nearly equal to the actual time taken to reach agreements. Thus, once again, in delay there is "no plenty."

Allowing incumbents to trade in spectrum licenses, even if they did not pay for them or actually have a reasonable expectation of the right to do so, allows market forces to reassign rights to the most valued users and uses in an expeditious manner. Yet, time is of the essence—delays caused by legacy licensees in search of higher prices impose a social cost from postponed broadband deployment.

Conclusion

As the federal government searches for more spectrum for modern, broadband uses, the lack of inventory makes it necessary for the FCC to repurpose spectrum from existing users and users. Allowing incumbents to trade in spectrum licenses, even if they did not pay for them or actually have a reasonable expectation of the right to do so, allows market forces to reassign rights to the most valued users and uses in an expeditious manner. Yet, time is of the essence—delays caused by legacy licensees in search of higher prices impose a social cost from postponed broadband deployment.

In this PERSPECTIVE, we present a simple, two-stage bargaining model that provides some guidance for policymakers. To expedite the expansion of broadband services, once spectrum is identified as suitable for repurposing, a transaction window is opened, allowing legacy licensees to transact in licenses. Avoiding unnecessary strategic delay by legacy licensees encourages closing this transaction window at a fixed date, at which time incumbent licenses yet to serve the repurposing goal are, in effect, reclaimed, and these incumbent license holders are provided compensation established by the Commission. This level of compensation, if set properly, motivates legacy licensees to act in the first period, thus permitting the spectrum to generate social benefits more quickly. A sensible compensation level, if history is any guide, is to relocate incumbents to new spectrum providing benefits equal to the initial use of the property.

NOTES:

* **Professor T. Randolph Beard** *is a Senior Fellow with the Phoenix Center for Advanced Legal and Economic Public Policy Studies and a Professor of Economics at Auburn University.* **Dr. George S. Ford** *is the Chief Economist of the Phoenix Center for Advanced Legal and Economic Public Policy Studies. The views expressed in this Perspective do not represent the views of the Phoenix Center or its staff.*

[1] Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update: 2016-2021 (February 7, 2017) (available at: https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.pdf); *Ericsson Mobility Report*, Ericsson (June 2017) (available at: https://www.ericsson.com/assets/local/mobility-report/documents/2017/ericsson-mobility-report-june-2017.pdf); CTIA Annual Wireless Survey (available at: https://www.ctia.org/industry-data/ctia-annual-wireless-industry-survey).

[2] *See* T.R. Beard, G.S. Ford, L.J. Spiwak & M. Stern, *Market Mechanisms and the Efficient Use and Management of Scarce Spectrum Resources,* 66 FEDERAL COMMUNICATIONS LAW JOURNAL 263 (2014) *(available at:* http://www.fclj.org/wp-content/uploads/2014/06/66.2.2_Spiwak-Final.pdf*);* MOBILE NOW Act, S. 19, 115th Congress 1st Session (available at: https://www.congress.gov/115/bills/s19/BILLS-115s19es.pdf).

[3] J. Melvin, *FCC Approves Verizon Wireless' Cable Spectrum Deal*, REUTERS (August 23, 2012) (available at: https://www.reuters.com/article/us-verizon-cable-fcc/fcc-approves-verizon-wireless-cable-spectrum-deal-idUSBRE87M12X20120823); T.R. Beard, G.S. Ford, L.J. Spiwak, and M. Stern, *Taxation by Condition: Spectrum Repurposing at the FCC and the Prolonging of Spectrum Exhaust*, 8 HASTINGS SCIENCE AND TECHNOLOGY LAW JOURNAL 183-209 (2016) (available at: http://www.phoenix-center.org/papers/HastingsSTLJ-TaxationbyCondition.pdf).

[4] CONNECTING AMERICA: THE NATIONAL BROADBAND PLAN, Federal Communications Commission (March 16, 2010) (available at: http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-296935A1.pdf) at XIII (hereinafter "*National Broadband Plan*"); EXECUTIVE OFFICE OF THE PRESIDENT — PRESIDENT'S COUNCIL OF ADVISORS ON SCIENCE AND TECHNOLOGY, REPORT TO THE PRESIDENT: REALIZING THE FULL POTENTIAL OF GOVERNMENT-HELD SPECTRUM TO SPUR ECONOMIC GROWTH (July 2012), available at http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_spectrum_report_final_july_20_2012.pdf); NAT'L TELECOMM. & INFO. ADMIN., PLAN AND TIMETABLE TO MAKE AVAILABLE 500 MEGAHERTZ OF SPECTRUM FOR WIRELESS BROADBAND (Oct. 2010) (available at http://www.ntia.doc.gov/files/ntia/publications/tenyearplan_11152010.pdf); T.W. Hazlett, THE POLITICAL SPECTRUM: THE TUMULTUOUS LIBERATION OF WIRELESS TECHNOLOGY (Yale University Press 2017); T.R. Beard, G.S. Ford, L.J. Spiwak and M. Stern, *Eroding the Rule of Law: Regulation as Cooperative Bargaining at the FCC*, PHOENIX CENTER POLICY PAPER No. 49 (2015) (available at http://www.phoenix-center.org/pcpp/PCPP49Final.pdf).

[5] *National Broadband Plan, id.* at pp. 79-80.

[6] This approach is a sensible option, though others may be worth considering. *See, e.g.,* P. Goldstein, *IT'S OVER: FCC's AWS-3 Spectrum Auction Ends at Record $44.9B in Bids,* FIERCEWIRELESS (January 29, 2018) (available at: https://www.fiercewireless.com/wireless/it-s-over-fcc-s-aws-3-spectrum-auction-ends-at-record-44-9b-bids). More recently, the FCC has begun to employ incentive auctions, whereby incumbent users are compensated for voluntarily surrendering their licenses (an approach that may also require relocation of incumbents). But auctions take time, and time is the enemy. *See, e.g.,* Federal Communications Commission, *Broadcast Incentive Auction and Post-Auction Transition* (available at: https://www.fcc.gov/about-fcc/fcc-initiatives/incentive-auctions).

[7] *See, e.g.*, J.R. Commons, LEGAL FOUNDATIONS OF CAPITALISM (1924); R.H. Coase, *The Problem of Social Costs*, 3 JOURNAL OF LAW & ECONOMICS 1-44 (1960); G.D. Libecap, *Property Rights in Economic History: Implications for Research*, 23 EXPLORATIONS IN ECONOMIC HISTORY 227-252 (1986) (available at: https://pdfs.semanticscholar.org/ddec/72411b41951e084670626336a97e7508f127.pdf); R.H. Coase, *The Federal Communications Commission*, 2 JOURNAL OF LAW & ECONOMICS 1-40 (1959); T.W. Hazlett, *Assigning Property Rights to Radio Spectrum Users: Why Did FCC License Auctions Take 67 Years*, 41 JOURNAL OF LAW & ECONOMICS 529-576 (1998); Hazlett, *The Political Spectrum*, *supra* n. 4.

[8] *See, e.g.*, R. Earle and D.W. Sosa, *Spectrum Auctions Around the World: An Assessment of International Experiences with Auction Restrictions*, Analysis Group (July 2013) (available at: http://mobilefuture.org/wp-content/uploads/2013/07/Spectrum-Auctions-Around-The-World.pdf); C. LaCasse and R. Marsden, *International Trends in Spectrum Auctions: Implications for the Americas*, NERA Economic Consulting (October 15, 2012) (available at: http://www.nera.com/content/dam/nera/publications/archive2/PUB_Intl_Trends_Spectrum_Auctions_1012.pdf).

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[9] *In the Matter of Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, FCC 14-50, REPORT AND ORDER, 29 FCC Rcd. 6567 (rel. June 2, 2014) at ¶ 2 (available at: https://apps.fcc.gov/edocs_public/attachmatch/FCC-14-50A1.pdf).

[10] 47 U.S.C. § 309(j)(3)(D).

[11] Beard, *et al., Taxation by Condition, supra* n. 3.

[12] https://www.fcc.gov/auction/97.

[13] *Review of the Commission's Rules Governing the 896-901/935-940 MHz Band, Realignment of the 896-901/935-940 MHz Band to Create a Private Enterprise Broadband Allocation Amendment of the Commission's Rules to Allow for Specialized Mobile Radio Services Over 900 MHz Business/Industrial Land Transportation Frequencies,* FCC 17-108, NOTICE OF INQUIRY, 32 FCC Rcd 6421 (rel. Aug. 4, 2017) at ¶¶ 12 *et seq.* (available at: https://docs.fcc.gov/public/attachments/FCC-17-108A1.pdf); *Further Comments of Enterprise Wireless Alliance and PDVWireless, Inc.*, WT Docket No. 17-200 (May 1, 2018) (available at: https://ecfsapi.fcc.gov/file/10501075523973/EWA%20PDV%20Further%20Comments%2017-200%20%205-1-2018.pdf); M. Alleven, *EWA, pdvWireless Pitch New Game Plan for 900 MHz Spectrum*, FierceWireless (May 3, 2018) (available at: https://www.fiercewireless.com/wireless/pdvwireless-ewa-pitch-new-game-plan-for-900-mhz-spectrum).

[14] *See, e.g.*, 47 CFR § 101.73; 47 CFR § 101.69; and 47 CFR § 101.75.

[15] *See, e.g.*, TRANSITIONING BROADCASTERS AFTER THE AUCTIONS, Federal Communications Commission (available at: https://www.fcc.gov/about-fcc/fcc-initiatives/incentive-auctions/post-auction-transition).

[16] W. Shakespeare, TWELFTH NIGHT, Act 2, Scene 3 ("What is love? 'Tis not hereafter. Present mirth hath present laughter. What's to come is still unsure. In delay there lies no plenty.").

[17] For an analysis of repurposing with an interference externality, *see*, e.g., T.R. Beard, G.S. Ford and M. Stern, *Skin in the Game: Interference, Sunk Investment, and the Repurposing of Radio Spectrum*, PHOENIX CENTER POLICY BULLETIN No. 40 (March 2017) (available at: http://phoenix-center.org/PolicyBulletin/PCPB40Final.pdf).

[18] *See, e.g.*, A. E. Roth, J.K. Murnigham, and F. Schoumaker, *The Deadline Effect in Bargaining: Some Experimental Evidence*, 78 AMERICAN ECONOMIC REVIEW 806-23 (1988); A.R. Admati and M. Perry, *Strategic Delay in Bargaining*, 54 REVIEW OF ECONOMIC STUDIES 345-64 (1987); K. Binmore, M.J. Osborne, and A. Rubinstein, *Noncooperative Models of Bargaining*, in R.J. Aumann and S. Hart, eds., HANDBOOK OF GAME THEORY WITH ECONOMIC APPLICATIONS (1992); P.C. Cramton and J.S. Tracy, *Strikes and Holdouts in Wage Bargaining: Theory and Data*, 82 AMERICAN ECONOMIC REVIEW 100-121 (1992).