EXACTITUDE IN DEFINING RIGHTS: RADIO SPECTRUM AND THE "HARMFUL INTERFERENCE" CONUNDRUM

Thomas W. Hazlett[†] *and Sarah Oh*[††]

ABSTRACT

In the century since the Radio Act of 1912 initiated U.S. spectrum allocation rules, a precise definition of "harmful interference"—the control of which forms the rationale for regulation—has eluded policymakers. In one sense, that result is unsurprising; rights are always defined incompletely. In another sense, however, the regulatory system is dysfunctional, severely limiting the productive use of spectrum while locked down in years-long border disputes. These disagreements have, in turn, triggered calls to develop brighter lines and fuller engineering specifications of harmful interference. However, this emphasis on exact definitions is misguided. Spectrum use rights generate more robust market development when they feature technically fuzzy borders but are awarded in economically efficient bundles. The key ingredients are (a) exclusive, flexible rights; (b) frequency borders set via standardized edge emission limits; (c) large bundles of complementary rights that limit fragmentation; and (d) fluid secondary trading that allows mergers to end border disputes by eliminating borders. Regulators should focus less on delineating precise interference contours, and instead expeditiously distribute standard bandwidth rights to economically responsible agents, taking care to avoid undue fragmentation (and tragedy of the anti-commons). Many episodes illustrate these lessons, including those involving reallocation of the broadcast TV band, the emergence of HD radio, the Nextel/public safety "spectrum swap," and the ongoing WCS/SDARS dispute. Each instance reveals that economic incentives, not engineering complexity, drive—or block—productive coordination of radio spectrum use.

---

† Professor of Law and Economics, George Mason University School of Law; FCC Chief Economist, 1991–1992. This Article follows from a presentation on *Creating Efficient Spectrum Property, Towards an Economic Definition of "Harmful Interference" in Radio Transmissions*, Presentation at the Conference on Spectrum Markets: Challenges Ahead, Kellogg School of Management, Northwestern University (June 2–3, 2011). The author thanks Brent Skorup for excellent research assistance.

†† Research Fellow, Information Economy Project. Ph.D. Student in Economics, George Mason University; J.D. George Mason University; B.S. Stanford University, Management Science & Engineering.

TABLE OF CONTENTS

I. INTRODUCTION

> "Regardless of how or to whom particular rights are assigned, ensuring that all rights are *clearly delineated* is important to avoiding disputes, and provides a clear common framework from which spectrum users can negotiate alternative arrangements."
>
> –Federal Communications Commission (2002)[1]

> "Commenters . . . almost uniformly cited the FCC's interference rules as the prime example of rules that are not *clearly defined*. A common refrain was that the FCC rules speak of the right to be protected from "harmful interference," but this term is not defined in technical terms . . . ."
>
> –Federal Communications Commission (2002)[2]

A. THE CRISIS IN U.S. SPECTRUM POLICY

There is officially a crisis in U.S. spectrum policy. Congressionally chartered studies,[3] top U.S. policymakers,[4] and the Presidential Administration,[5] citing the need for additional wireless bandwidth for economic growth, have pushed for dramatic improvements in the process whereby the Federal Communications Commission ("FCC") allocates the radio spectrum. The emergence of wireless 3G and 4G data networks, as well as a slew of popular handsets and applications after the 2007 introduction of

1. FCC, SPECTRUM POLICY TASK FORCE REPORT, ET DOCKET NO. 02-135, 18 (Nov. 2002) [hereinafter SPTFR 2002] (emphasis added), *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-228542A1.pdf.

2. *Id.* (emphasis added).

3. The National Broadband Plan, issued by the FCC, was mandated in the American Recovery and Reconstruction Act of 2009 (also known as "the stimulus bill"). The FCC issued its report in March 2010; Chapter 5, "Spectrum," deals with the issues discussed in this Article. FCC, CONNECTING AMERICA: THE NATIONAL BROADBAND PLAN, CH. 5: SPECTRUM 73 (2010) [hereinafter NBP 2010], *available at* http://www.broadband.gov/download-plan/.

4. Lawrence H. Summers, Technological Opportunities, Job Creation, and Economic Growth, Remarks at the New America Foundation on the President's Spectrum Initiative (June 28, 2010), http://www.whitehouse.gov/administration/eop/nec/speeches/technological-opportunities-job-creation-economic-growth; Julius Genachowski, Chairman, Federal Communications Commission, Prepared Remarks for the 2011 International Consumer Electronics Show (Jan. 7, 2011), http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-303984A1.pdf.

5. White House, Office of the Press Secretary, Presidential Memorandum: Unleashing the Wireless Broadband Revolution (June 28, 2010), http://www.whitehouse.gov/the-press-office/presidential-memorandum-unleashing-wireless-broadband-revolution.

the iPhone, triggered a "mobile data tsunami" that has prompted policy makers to respond to the demands of the market.[6]

But institutional stasis hampers this effort at virtually every step. In March 2010, the National Broadband Plan set a goal of making available another 300 MHz of spectrum (a bit more than one-half of that currently available to mobile carriers) by 2015.[7] Yet today, every one of the proceedings comprising that plan is either behind schedule or has been abandoned.[8] Scholars are unshaken in their assessment that "[t]he FCC's traditional system for managing the radio spectrum is a paradigm of economic inefficiency."[9]

Prominent communications experts advance the following diagnosis of the underlying problem: Regulators have failed in the century of radio regulation since the Radio Act of 1912[10] to precisely define radio "interference."[11] Such conflicts have been of central importance to regulators, who are charged with creating rules for wireless operations that avoid the "tragedy of the commons."[12] Arguably, the delineation of border

6. *See* Thomas W. Hazlett, Roberto E. Muñoz & Diego B. Avanzini, *What Really Matters in Spectrum Allocation Design*, 10 NW. J. TECH. & INTELL. PROP. 93, 95 (2012).

7. *See* NBP 2010, *supra* note 3, at 75.

8. This assessment is per FCC Commissioner Ajit Pai. *See* John Eggerton, *Pai Concerned About Where FCC Is Headed on Big Issues*, BROADCASTING & CABLE (July 18, 2012, 10:59 AM), http://www.broadcastingcable.com/article/487370-Pai_Concerned_About_Where_FCC_Is_Headed_on_Big_Issues_.php.

9. Dale Hatfield & Phil Weiser, *Toward Property Rights in Spectrum: The Difficult Policy Choices Ahead*, CATO INST. POL'Y ANALYSIS NO. 575, at 4 (Aug. 17, 2006).

10. The Radio Act instructed the Secretary of Commerce & Labor to issue licenses to those wishing to transmit radio signals, and in doing so to "minimize interference." This authority remained with the Department of Commerce when the Department of Labor was split off in 1913. Radio Act of 1912, CH. 287, § 4, P.L. NO. 264, 37 STAT. 302 (1912) ("That for the purpose of preventing or minimizing interference . . . said private and commercial stations shall be subject to the regulations of this section. These regulations shall be enforced by the Secretary of Commerce and Labor . . . ."); An Act to Create a Department of Labor, P.L. NO. 62-426, § 1, 37 STAT. 736 (1913).

11. 47 C.F.R. § 2.1 (2010) ("Harmful Interference[:] [i]nterference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with [the ITU] Radio Regulations."); *see also id.* ("Accepted Interference[:] [i]nterference at a higher level than defined as permissible interference and which has been agreed upon between two or more administrations without prejudice to other administrations.") (citation omitted).

12. The "tragedy of the commons" relates to a situation in which the distribution of ownership rights preempts resource optimization. The classic formulation, by biologist Garrett Hardin, focuses on the "over-grazing" problem in a pasture that is, effectively, owned by no one. A better description of the resulting inefficiency would have been, "tragedy of open access." *See* Garrett Hardin, *Tragedy of the Commons*, 162 SCIENCE 1243

conditions (demarcation of where one set of wireless users' rights ends and another begins) has become increasingly important. Not only have wireless services become far more widespread, and spectrum deployments much more economically important, but key wireless licenses—specifically, those authorizing mobile voice and data networks—have been dramatically liberalized in recent decades. The combination of significantly increasing wireless traffic and delegation of spectrum use choices to decentralized private actors leads many to insist that regulators must get far more serious about specifying the precise boundaries delimiting use rights.

B. EXACTITUDE IN SPECTRUM USE RIGHTS BOUNDARIES AT THE FCC

Theoretically, the FCC endorses exactitude: "Regardless of how or to whom particular rights are assigned, ensuring that all rights are clearly delineated is important to avoiding disputes."[13] Yet competitive economic forces point in exactly the reverse direction. Where particular rights are assigned to responsible economic agents in packages that avoid excessive fragmentation, "clearly delineated" rights are not much needed. Rather, approximately defined spectrum rights can be sufficient to launch markets. Self-interested actors then help to govern the delicate edges, between which—or through—intense airwave conflicts occur. These agents are rewarded by the net value of the traffic they generate, and are incentivized to discover how to efficiently mitigate mutually exclusive claims. Bureaucrats crafting use rights so as to avoid harmful interference have neither access to such information, nor the means to acquire it. As economist Thomas Sowell laments: "Why the transfer of decisions from those with personal experience and a stake in the outcome to those with neither can be expected to lead to better decisions is a question seldom asked, much less answered."[14]

In radio spectrum the question of how to precisely define spectrum rights is often raised, but then buried beneath an underlying assumption that the distribution of all additional rights should be delayed until greater

(1968); Thráinn Eggertsson, *Open Access Versus Common Property*, *in* PROPERTY RIGHTS: COOPERATION, CONFLICT AND LAW 75 (Terry L. Anderson & Fred S. McChesney eds., 2002). The term "anticommons" is also used to describe situations where complementary rights are too widely distributed, preventing the emergence of efficient economic activity. The problem, however, is simply a reverse angle on the initial formulation by Hardin. *See* Michael Heller, *The Tragedy of the Anticommons: Property in the Transition from Marx to Markets*, 111 HARV. L. REV. 621 (1998); Lee Anne Fennell, *Common Interest Tragedies*, 98 NW. L. REV. 907 (2004).

13. SPTFR 2002, *supra* note 1, at 17–18.

14. THOMAS SOWELL, INTELLECTUALS AND SOCIETY 19 (2011).

exactitude can be specified.[15] Even leading champions of further liberalization—sometimes identified as a shift to "private property spectrum"[16]—caution that "inexact" borders, without articulation of the diminishing returns of exactitude, will stifle the growth of wireless networks.[17] The claim is made as a categorical proposition without considering the alternative costs of delaying market development. In fact, certainty is never achieved in drafting property rights or contracts, criminal laws, or liability rules. The quest to refine spectrum use contours is socially costly.[18] The relevant comparison, therefore, is not between approximate use rights and a theoretically ideal set of precise, fully-specified spectrum use rights covering all dimensions over which frequencies may be usefully deployed (including those yet to be discovered). Rather, the relevant comparison is between continuing administrative control and decentralized choices made by profit-seeking operators who possess incomplete spectrum rights.

C. THE FCC'S APPROACH TO SPECTRUM USE RIGHTS DEFINITIONS

As shown in the FCC comments above, policymakers claim the following paradox: (a) harmful interference, defining the contours of spectrum use rights, must be clearly and fully detailed for wireless markets to work efficiently; (b) this feat has never been achieved; (c) mobile markets are

15. Hatfield and Weiser make this argument for proceeding slowly and carefully, despite their admission that "[t]he FCC's traditional system for managing the radio spectrum is a paradigm of economic inefficiency." Hatfield & Weiser, *supra* note 9, at 4.

16. MICHAEL HELLER, THE GRIDLOCK ECONOMY 89 (2008) (The evolution of private-property spectrum has come via wireless "licenses that look a lot like ordinary private property. Bands are exclusively assigned. Licensees may manage this spectrum with a measure of autonomy. Flexible uses are allowed. License holders may change technologies, services and business models to maximize their own profits—much as ordinary merchants shift inventory in bricks-and-mortar stores.").

17. Philip J. Weiser & Dale Hatfield, *Spectrum Policy Reform and the Next Frontier of Property Rights*, 15 GEO. MASON L. REV. 549, 550–51 (2008) ("Commentators have recognized the need for reform . . . [but] a poorly designed property rights regime for spectrum might even be worse than the legacy model of spectrum regulation.").

18. For more on property and the costs and gains of border definition, see Thomas W. Merrill, *Property as Modularity*, 125 HARV. L. REV. F. 151 (2012) ("Exclusion does more than minimize information costs for third parties. Even more importantly, it gives the owner residual managerial authority and residual accessionary rights—the rights to sow and to reap what has been sown."), a response to frequent co-author, Henry E. Smith, *Property as the Law of Things*, 125 HARV. L. REV. 1691 (2012) [hereinafter Smith, *Property as the Law of Things*]. Merrill and Smith are leading voices on definitional efficiency in property law. *See generally* Thomas W. Merrill & Henry E. Smith, *Optimal Standardization in the Law of Property: The* Numerus Clausus *Principle*, 110 YALE L.J. 1 (2000); Thomas W. Merrill & Henry E. Smith, *The Property/Contract Interface*, 101 COLUM. L. REV. 773 (2001).

nevertheless robust: "U.S. consumers continue to reap significant benefits—including low prices, new technologies, improved service quality, and choice among providers—from competition in the [mobile] marketplace . . . ."[19]

This botched syllogism reveals critical truths. The latter two points are factually correct—(b) border contours in spectrum allocations are inexact, and (c) large-scale networks, created by private capital, host intense economic activity that generates extremely high social value. This latter contribution to economic welfare, moreover, is intrinsically related to the manner in which the underlying frequency space ("mobile spectrum") is defined, with flexible use authorized for an exclusive licensee. As the FCC has seen fit to note, no other regulatory model that it employs could plausibly achieve such results.[20]

To wait six years for a superior specification of spectrum use rights eliminates 25.4% of the total social value of a project, assuming a 5% social discount rate.[21] Six years is, in the FCC's estimate, a lower bound on how long spectrum allocations take.[22] And there is no guarantee that such delays improve the delineation rights much (if at all). Indeed, the stronger inference is that, by avoiding templates in favor of customizing each allocation case by case, regulators who are dependent on data from key participants in the legal/lobbying process may obscure the path to simple, predictable harmful interference rules that could streamline allocations and put more spectrum in far more productive use.

---

19. In the Matter of Implementation of § 6002(b) of the Omnibus Budget Reconciliation Act of 1993 Annual Report and Analysis of Competitive Market Conditions With Respect to Commercial Mobile Services, Thirteenth Report, 24 FCC Rcd. 6185, 6189 ¶ 1 (2009), *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-09-54A1.pdf.

20. *Wireless Bureau Chief Daniel Phythyon Hails Success of Market-Based Spectrum Policies*, FCC (Sept. 11, 1997), http://transition.fcc.gov/Bureaus/Wireless/News_Releases/1997/nrwl7037.html (The Wireless Telecommunications Bureau, through spectrum auctions, "has successfully moved wireless services towards a flexible, competitively neutral regulatory scheme that has resulted in an unprecedented growth in the number of new service offerings and providers . . . . Permitting CMRS providers to offer fixed wireless services on a co-primary basis with mobile services has afforded them flexibility to meet consumer demand for fixed services, mobile services, and combinations of the two. A number of PCS licensees and other CMRS providers are developing fixed as well as mobile service offerings."). *See generally* In the Matter of Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993 Annual Report and Analysis of Competitive Market Conditions With Respect to Commercial Mobile Services, Fifteenth Report, 26 FCC Rcd. 9664 (2011) [hereinafter Fifteenth Annual Competition Report], *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-11-103A1.pdf.

21. The net present value of a six-year delay at a 5% discount rate is calculated 1-1/(1.05^6).

22. The FCC's National Broadband Plan found that such allocations take six to thirteen years. NBP 2010, *supra* note 3, at 79.

Incomplete rights, when assigned with sufficient scope to yield effective spectrum ownership rights, power cellular markets.[23] These markets enable rapid economic growth in the United States[24] and internationally, particularly in developing economies.[25] Notably, such markets coordinate continual spectrum redeployments. Under traditional regulation, new services, network architectures, business models, and technologies are subject to regulatory approval. In this process, government agencies consider whether proposed changes are in the public interest and, in particular, whether the change would result in harmful interference with other wireless activities. Typically, such deliberations encompass competitive concerns—meaning that competitors widely object to granting rivals new authority to change service offerings. The FCC itself has become an attractive nuisance, allowing spectrum use decisions to serve anti-competitive firm strategies. Leading FCC officials themselves have bemoaned the fact, citing the term "Forever Captured by Corporations" as the operational reality.[26]

A better system is one in which private wireless operators, rather than regulators, make decisions about spectrum use. Under the flexible uses permitted to Commercial Mobile Radio Services ("CMRS") licensees,[27] technical considerations have been delegated to wireless operators themselves. Within the bandwidth allocated to their licenses, carriers coordinate complex activities that involve extensive spectrum sharing. In emission spillovers with bandwidth allocated to other carriers' licenses, operators routinely negotiate win-win agreements to deal with radio

23. This Article uses the terms "cellular markets," "mobile markets," "wireless markets," "CMRS" (commercial mobile radio services, an FCC acronym), "PCS" (personal communications service, an FCC acronym), "3G," "4G," and "3G/4G," interchangeably, except as otherwise noted. "G" in the preceding abbreviations stands for "Generation."

24. At least $200 billion in U.S. consumer surplus is generated annually by the use of mobile voice services. Rapidly evolving mobile data services (via smartphones, tablets, netbooks, notebooks and M2M—"machine to machine"—devices) are on top of this sum. Hazlett, Muñoz & Avanzini, *supra* note 6, at 100 (noting that $211.8 billion in U.S. consumer surplus was generated in 2009 (in 2008 dollars)). It is estimated that, in 2011, mobile services added about $146 billion to GDP, accounting (directly and indirectly) for nearly four million jobs. ROGER ENTNER, THE WIRELESS INDUSTRY: THE ESSENTIAL ENGINE OF U.S. ECONOMIC GROWTH 4, 14 (2012), http://reconanalytics.com/wp-content/uploads/2012/04/Wireless-The-Ubiquitous-Engine-by-Recon-Analytics-1.pdf.

25. *See, e.g.*, Leonard Waverman et al., Presentation at the IFC Seminar: The Socio-Economic Impact of Mobile Phones in Africa (May 6, 2005), http://info.worldbank.org/etools/BSPAN/PresentationView.asp?PID=1522&EID=741; Sara Corbett, *Can the Cellphone Help End Global Poverty?*, N.Y. TIMES, Apr. 13, 2008, at MM34; Robert Jensen, *The Digital Provide: Information (Technology), Market Performance, and Welfare in the South Indian Fisheries Sector*, 122 Q. J. OF ECON. 879 (2007).

26. Ken Auletta, *The News Rush*, NEW YORKER, Mar. 18, 1996, at 42.

27. 47 C.F.R. § 20.3 (2011); *see generally infra* note 28.

conflicts.[28] And, more importantly, the vast majority of potential conflicts are remedied by the aggregation of spectrum rights: U.S. mobile operators hold well over 50,000 CMRS licenses, creating national and regional networks that largely eliminate border disputes by eliminating borders themselves.[29]

CMRS licenses define radio spectrum rights far more liberally than do traditional FCC licenses, which narrowly specify what wireless users can do. Historically, traditional licenses have been called "radio station authorizations," and have been analogous to *use permits* rather than *spectrum licenses*.[30] That is because the underlying resource, radio spectrum, was under the control of regulators, not licensees. The operator could only transmit (or receive) wireless signals as permitted. Regulators determined where transmissions could take place, what frequency and emitted power they would use, with which technologies they would operate, and what services would be supplied. These regulators even decided which business models (e.g., subscription versus ad-supported, common carrier versus private carrier, etc.) were deployed.[31] The development of mobile phone networks saw a relaxation of such rules, which transitioned from in personam use rights (specified by the FCC) to in rem spectrum ownership rights. The latter

---

28. An executive for Verizon Wireless describes the manner in which disputes among mobile networks are resolved:

> Under current rules, licensees negotiate to extend rights into each others' licensed spectrum on a daily basis. These . . . involve hundreds of individual negotiations between companies' engineers who are tasked with the day-to-day operations of the network . . . . [T]here is no benefit to seeking regulatory redress.

Charla Rath, *Defining Radio Rights: Theory and Practice*, *in* J. Pierre de Vries & Kaleb A. Sieh, *The Unfinished Radio Revolution: Eight Perspectives on Wireless Interference Symposium*, 9 J. TELECOM. & HIGH-TECH. L. 501, 529 (2011). It is of interest that Rath attributes the satisfactory process of dispute resolution to the fact that "the rights of both licensees are clear." *Id.* In fact, the rights are *clear enough* such that Verizon Wireless and other carriers may create and operate large networks, but the border definitions are themselves fairly cryptic and are defined in four dimensions—frequency, power at the edge, geography, and time. Various spectrum experts recommend defining borders in more than four dimensions, as discussed *infra* note 56 and accompanying text.

29. Thomas W. Hazlett, *Is Federal Preemption Efficient in Cellular Phone Regulation*?, 56 FED. COMM. L.J. 155, 193 (2003) [hereinafter Hazlett, *Federal Preemption*]. In 2003, the count for U.S. CMRS licenses was 51,597. *Id.* Since that time, 1,087 were issued in the 2006 auction of Advanced Wireless Service (AWS) licenses and another 1,090 in the 2008 auction of 700 MHz licenses. *Auctions Summary*, FCC, http://wireless.fcc.gov/auctions/default.htm?job=auctions_all.

30. Thomas W. Hazlett, *The Wireless Craze, the Unlimited Bandwidth Myth, the Spectrum Auction Faux Pas, and the Punchline to Ronald Coase's 'Big Joke': An Essay on Airwave Allocation Policy*, 14 HARV. J.L. & TECH. 335 (2001) [hereinafter Hazlett, *Wireless Craze*].

31. *Id.*

cede greater scope to rights holders to determine resource uses.[32] This creates net benefits when regulatory rules are relatively inefficient, even as it increases the direct costs of defining rights: "in rem rights conserve on information when it is cheaper to define the resource itself and appoint a single manager (the owner) who has the discretion to choose among multiple permitted uses."[33]

D. LIBERAL LICENSES THAT REMEDY TRAGEDIES OF THE ANTI-COMMONS

One major reason for the policy change in cellular communications was the greatly increased complexity of the network architectures[34] over previous wireless services such as broadcasting or point-to-point microwave relays. Modern U.S. mobile networks construct 50,000 or more base stations, distribute hundreds of millions of mobile handsets to subscribers using matching technologies, build high-capacity (fixed) links connecting wireless calls to multiple voice and data networks, and supply platforms for the operation of additional millions of applications and machine-to-machine devices.[35] The coordination requirements are large. Competitive forces push efficiency and innovation in these busy ecosystems, discovering trade-offs unknown to disinterested observers and illustrating the information cost savings enabled by delegating resource decisions to profit-seeking licensees.[36]

Years prior to the deregulatory actions yielding "flexible-use" spectrum rights, scholars argued on theoretical grounds for such a policy. In papers

32. Merrill & Smith, *The Property/Contract Interface*, *supra* note 18, at 778.

33. *Id.*

34. This theory is elaborated upon in Thomas W. Hazlett, *Assigning Property Rights to Radio Spectrum Users: Why Did FCC License Auctions Take 67 Years?*, 41 J.L. & ECON. 529 (1998). One of the major outcomes of the liberalized approach to spectrum regulation was the introduction of license auctions in the United States and at least thirty other countries—a trend coincident with the rise of cellular networks. *Id.*

35. Thomas W. Hazlett, David J. Teece & Leonard Waverman, *Walled Garden Rivalry: The Creation of Mobile Network Ecosystems*, George Mason Law & Economics Research Paper No. 11-50 (Nov. 22, 2011) (paper presented at CITI, Columbia University (Oct. 14, 2011)).

36. *See* Julius Genachowski, Chairman, FCC, Prepared Remarks for the GSMA World Congress, Barcelona (Feb. 27, 2012), http://www.fcc.gov/document/chairman-genachowskis-remarks-gsma-mobile-world-congress ("490 million smartphones were sold worldwide in 2011, exceeding the number of PCs sold over the same period."); Julius Genachowski, Chairman, FCC, Prepared Remarks for the Broadband Acceleration Conference, Washington D.C. (Feb. 9, 2011), http://www.fcc.gov/document/prepared-remarks-chairman-julius-genachowski-federal-communications-commission-broadband-ac ("It has also been estimated that removing red tape and expediting approval processes could unleash $11.5 billion in new broadband infrastructure investment over two years.").

written in 1962[37] and 1969,[38] such researchers considered, *tabula rasa*, how spectrum ownership rights could be defined with respect to three variables: time (T), geographic area (A), and frequency (S)—a "TAS package."[39] Even as a theoretical exercise, the components of what has proven successful in CMRS licenses were presented, including the specification of maximum field strength at geographic and frequency boundaries.[40] Today, scholars still use these bundles to shape appropriate rights packages, even in sophisticated discussions of how to achieve efficient economic outcomes in wireless markets.[41] As developed over the past several decades, the FCC has crafted CMRS (including cellular and PCS) license rights to authorize delivery of wireless services of any type, technology, or business model, limited by emission boundaries.[42] These rights have formed the resource rights used to generate far more consumer welfare in the wireless sector than any competing method and, more importantly, to significantly out-perform any alternative rights regime yet considered.

That borders are not costless to define or police, however, raises another important consideration. In defining and distributing spectrum rights, methods that permit license aggregation serve a valuable function. In integrating ownership, borders are reduced and border disputes eliminated—"since there is no externality if ownership is unified . . . [t]o merge or not to

37. RONALD COASE, WILLIAM H. MECKLING & JORA MINASIAN, PROBLEMS OF RADIO FREQUENCY ALLOCATION (1995), http://www.rand.org/pubs/drafts/DRU1219.html. This monograph, published in 1995, was written in May 1963. *See also* Thomas W. Merrill & Henry S. Smith, *Making Coasean Property More Coasean*, 54 J.L. & ECON. S77, S85 n.6 (2011) (describing the delay in public release).

38. Arthur S. De Vany, Ross D. Eckert, Charles J. Meyers, Donald J. O'Hara & Richard C. Scott, *A Property System for Market Allocation of the Electromagnetic Spectrum: A Legal-Economic-Engineering Study*, 21 STAN. L. REV. 1499 (1969).

39. *Id.* at 1501.

40. *Id.* at 1513–17.

41. *See, e.g.*, Timothy K. Forde & Linda E. Doyle, *A Combinatorial Clock Auction for OFDMA-based Cognitive Wireless Networks*, *in* PROCEEDINGS OF 3RD INTERNATIONAL SYMPOSIUM ON WIRELESS PERVASIVE COMPUTING 329, 329–33 (May 7–9, 2008), http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=4556224.

42. As FCC experts Evan Kwerel and John Williams have written: "[W]e suggest setting objective limits on some of the principal factors that cause interference (*e.g.*, transmitter power at boundaries) and allowing licensees to deploy unilaterally, and control actual interference, within those limits . . . . The values used in the current PCS rules should be appropriate in most instances." Evan Kwerel & John Williams, *A Proposal for a Rapid Transition to Market Allocation of Spectrum* 44–45 (FCC, OPP Working Paper No. 38, Nov. 15, 2002), *available at* http://wireless.fcc.gov/auctions/conferences/combin2003/papers/masterevanjohn.pdf. The passage cites to the FCC's PCS boundary rules: 47 C.F.R. §§ 24.236, 24.238 (2001).

merge ownership interests is the question."[43] It is appropriate here to cite the Demsetzian critique of Coase's analysis. Coase assumed, as have many others, that market structure is exogenous. In instances where small numbers of parties were involved in a spillover problem—for example, a doctor and a confectioner occupying adjacent quarters[44]—negotiations to maximize social welfare were seen as likely to occur. Where, however, large numbers of parties were affected by a given activity—for example, many farmers absorbing pollution from a railroad[45]—Coase readily conceded that government regulation might be preferred. With legal rights widely dispersed, transaction costs stymie the "correction" of externalities; spillovers that produce less value than the productivity they destroy will continue because the expense of fixing them (bargaining between parties) outweighs the benefits that could be gained.[46]

Demsetz observes, however, that *given* fragmented ownership rights, the efficient solution is achieved by *not remedying* the externality. "A decision that something is not worth taking into account is not, because of this, a source of inefficiency."[47] Hence, no "market failure" exists. The more efficient distribution of legal rights might improve social outcomes. That is to say, markets are decentralized either because there are relatively important advantages that accrue from decentralization (for example, the costs of managing larger businesses are avoided, a situation where diseconomies of scale obtain), or because legislators, courts, or regulators have chosen to create rights that impose uneconomic barriers to aggregation. This

43. Harold Demsetz, *Ownership and the Externality Problem*, *in* PROPERTY RIGHTS: COOPERATION, CONFLICT, AND LAW 282, 287 (Terry L. Anderson and Fred S. McChesney eds., Princeton University Press 2003).

44. Ronald H. Coase, *The Problem of Social Cost*, 3 J.L. & ECON. 1, 8–10 (1960) (citing *Sturges v. Bridgman*, 11 Ch.D. 852 (1879)).

45. *Id.* at 29–34 n.41 (citing 31 HALSBURY, LAWS OF ENGLAND 474–75 (3d ed. 1960)).

46. For an account of the Eureka moment witnessed by the twenty-one Chicago economists who attended Coase's talk on the subject of his paper on "externalities" in the living room of Aaron Director, greeted by unanimous hostility but, within two hours, producing stunning consensus, see GEORGE STIGLER, MEMOIRS OF AN UNREGULATED ECONOMIST (1982) and Steven G. Medema, *A Case of Mistaken Identity: George Stigler, "The Problem of Social Cost," and the Coase Theorem*, 31 EURO. J.L. & ECON. 11, 22–23 (2011). The economists engaged in this intellectual event included George Stigler, Aaron Director, Reuben Kessel, Milton Friedman, Gregg Lewis, Arnold Harberger, and Martin Bailey, among others, which Stigler remarked as "one of the most exciting intellectual events of my life." *Id.* at 24 (citing Edmund W. Kitsch, *The Fire of Truth: A Remembrance of Law and Economics at Chicago, 1932–1970*, 26 J.L. & ECON. 163 (1983)).

47. Harold Demsetz, *The Problem of Social Cost: What Problem? A Critique of the Reasoning of A.C. Pigou and R.H. Coase*, 7 REV. L. & ECON. 1, 10 (2011).

inefficiency flows from a standard anti-commons tragedy, and is fully illustrated in numerous FCC spectrum allocations.[48]

Common characteristics of these anti-commons "gridlock" situations are: highly fragmented rights, in personam rights, and licenses held by non-profit organizations. In such situations, regulatory methods and restrictions block markets from rearranging rights or restructuring markets, such that self-interested economic parties can mitigate border disputes. These restrictions ensure that one or more of the parties involved in a border dispute are severely restricted in their access to financial markets. Whereas a profit-seeking firm could raise capital (debt or equity) to buy up TV licenses (for example, moving TV broadcasts to alternative frequencies or video delivery platforms to unleash the radio spectrum allocated to the stations for higher valued uses, thus paying back investors and reaping, with luck, a profitable residual), the process is thwarted when TV licenses are locked into TV broadcasting. Society is left to develop means to mimic the role of financial markets,[49] or to devise policies that expand the spectrum use rights owned by responsible economic agents.[50]

E. DEFINING HARMFUL INTERFERENCE AS IF ECONOMICS MATTERS

The Demsetz critique—that because fragmented ownership rights exist, efficiency is achieved by not remedying externalities—has deep salience when considering how spectrum rights are usefully defined.[51] The manner in which productive economic activity will result from the creation of rights crafted by regulators is key, and it cannot be assumed that the dispersion of rights—or,

48. *See* HELLER, *supra* note 16. In particular, Chapter 4 deals with anti-commons in wireless. For a discussion on the tragedy of the anti-commons, see *infra* note 93.

49. This is what the FCC's National Broadband Plan attempted in advocating an "incentive auction." The procedure, authorized by a congressional statute in early 2012, has the regulatory agency conducting two sets of auctions. In the first, a reverse auction, TV stations state offer prices to exit broadcasting. In the second, the spectrum made available (by the vacating stations and a relocation plan implemented by the FCC for stations that remain) in the TV Band is reallocated to flexible-use licenses, which are sold in a forward auction. *See* In the Matter of Expanding the Econ. & Innovation Opportunities of Spectrum Through Incentive Auctions, Notice of Proposed Rulemaking, 27 FCC Rcd. 12,357 (2012), *available at* http://apps.fcc.gov/ecfs/document/view?id=7022026834 [hereinafter 2012 Incentive Auction NPRM]; H.R. Rep. No. 112-399 (2012) (Conf. Rep.). For an overview, see THOMAS W. HAZLETT, DAVID PORTER & VERNON SMITH, "INCENTIVE AUCTIONS"—ECONOMIC AND STRATEGIC ISSUES (2012) [hereinafter HAZLETT ET AL., INCENTIVE AUCTIONS PAPER], *available at* http://www.arlingtoneconomics.com/studies/WhitePaper.pdf.

50. *See, e.g.*, Thomas W. Hazlett, *Unleashing the DTV Band: A Proposal for an Overlay Auction*, Comment to the FCC, NBP Public Notice No. 26 (Dec. 18, 2009) [hereinafter Hazlett, *A Proposal for an Overlay Auction*], http://mason.gmu.edu/~thazlett/pubs/NBP_PublicNotice26_DTVBand.pdf.

51. *See infra* note 60.

if preferred, market structure—is exogenous. Regulators are perfectly capable of spreading rights to a large number of parties that cannot economically coordinate, of truncating rights issued to licensees such that market participants are prevented from using the most efficient methods, and of using authority over license transfers to delay or deter the useful aggregation of rights. Focusing on what policies regulators should pursue so as to define spectrum use rights—abstracting from the use of those rights to aid coordination on the one hand, and enabling production efficiencies on the other—leads analysts to completely miss the central components of the harmful interference policy question.

This Article addresses the crisis in spectrum allocation as a property rights conundrum. In Part I, we critiqued the common reasoning that a lack of clarity in defining the term "harmful interference" accounts, in large measure, for gridlock. However, we argued that the answer to the harmful interference problem in spectrum allocation is not greater exactitude in rights delineation, but rather the delegation of exclusive, flexible use rights to responsible economic agents. In Part II of this Article, we illustrate the FCC's position on "exactitude"—the idea that the regulator bears the burden to clearly define spectrum usage rights for parties to avoid harmful interference and best utilize radio spectrum. The FCC's approach to spectrum use rights boundaries is responsible for endemic failure and costly administrative delay. In Part III, we provide examples of situations in which the FCC's search for exactitude failed, and examples of situations in which exact-enough border definitions generated economic robustness. In Part IV, we propose specific ways in which spectrum use rights can optimally be defined to both avoid the harmful interference problem and promote social utilization.

II. EXACTITUDE

Despite game-changing mobile markets arising from the deployment of liberal CMRS licenses, the dominant meme among policy experts[52] and

52. In fairness, not all spectrum policy scholars espouse this view. Counter-examples include MARTIN CAVE, SPECTRUM MANAGEMENT FOR A CONVERGING WORLD: CASE STUDY ON THE UNITED KINGDOM (2006), http://www.itu.int/osg/spu/ni/spectrum/UK-RSM.pdf; Stuart M. Benjamin, *Spectrum Abundance and the Choice between Private and Public Control*, 78 N.Y.U. L. REV. 2007 (2003); Gregory L. Rosston, *The Long and Winding Road: The FCC Paves the Path With Good Intentions*, 27 TELECOMM. POL'Y 501 (Aug. 2003), http://www-siepr.stanford.edu/papers/pdf/01-08.pdf; Gerald R. Faulhaber, *The Future of Wireless Communications: Spectrum as a Critical Resource*, 18 INFO. ECON. & POL'Y 256 (Sept. 2006); John Mayo & Scott Wallsten, *Enabling Efficient Wireless Communications: The Role of Secondary Spectrum Markets*, 22 INFO. ECON. & POL'Y 61 (2010); Hazlett, Muñoz & Avanzini, *supra* note 6.

regulatory officials[53] is that, going forward, superior utilization of radio spectrum depends upon clear improvement, or "exactitude," in the technical specification of usage rights. Ellen Goodman asserts that, "[e]fficient conflict resolution requires that initial entitlements be state[d] precisely in the license (or license-free allocation),"[54] noting that we are failing to make much progress in this respect, as spectrum rights are still issued "without clear entitlements . . . [and are] lacking in the regularity and transparency that would facilitate secondary markets."[55] Robert Matheson and Adele Morris propose a seven-dimensional format for fully defining "electrospace" units, arguing that rights must be "flexible, exhaustive, and economically efficient."[56] Pierre De Vries and Kaleb Sieh, in a 2011 paper that seeks to create a framework for "unambiguously defining and delegating radio rights," posit:

> Clear rules are essential for radio coexistence and particularly important where conflict is more likely due to proximity in time, space or frequency; different technologies or business models; frequent change in operating parameters or operators; and multiple steps of delegation in the right to operate.[57]

The concern over definitional clarity is driven by two identified concerns:

1. *Interference Disputes*. There have been quagmires in regulatory proceedings as to what constitutes harmful interference, including proceedings involving Nextel and public safety radio users, Wireless Communications Services ("WCS") and Satellite Digital Audio Radio Services ("SDARS") licensees, L Band LTE users (LightSquared), and Geopositioning Satellite Services ("GPS").
2. *White Spaces*. Radio sensing technologies increasingly support spectrum sharing.[58] When a licensed service "consumes" less than all of the communications capacity of a given frequency space, it

53. A notable exception is *A Proposal for a Rapid Transition to Market Allocation of Spectrum*. Kwerel & Williams, *supra* note 42.

54. Ellen P. Goodman, *Progress Toward Rational Spectrum Rights: Are We Getting Anywhere?*, 9 J. TELECOMM. & HIGH-TECH. L. 505, 506 (2011).

55. *Id.*

56. Robert Matheson & Adele Morris, *The Technical Basis for Spectrum Rights: Policies to Enhance Market Efficiency* 40 (Brookings, 2011), *available at* http://www.brookings.edu/~/media/research/files/papers/2011/3/03%20spectrum%20rights%20matheson%20morris/0303_spectrum_rights_matheson_morris.pdf.

57. J. PIERRE DE VRIES & KALEB A. SIEH, THE THREE PS: INCREASING CONCURRENT OPERATION BY UNAMBIGUOUSLY DEFINING AND DELEGATING RADIO RIGHTS (2011) (paper presented at the IEEE International Symposium on Dynamic Spectrum Access Networks), *available at* http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5936248.

58. 47 C.F.R. § 15.703(l) (2011).

> leaves open the possibility that if there were rules in place that better defined harmful interference, additional radios could opportunistically transmit in the unused "white spaces," using rules for unlicensed device operation.[59]

Both inferences are misleading. First, additional clarity in spectrum rights (as with property rights generally) is preferred to less clarity, all else equal. But perfect clarity (or exhaustiveness) is not achievable, and additional clarity is costly. After basic use rights (such as with a critical mass, like TAS) are established, the cost of further specification of spectrum rights rises sharply.[60] As De Vany et al. wrote in their 1969 study, "[c]omplete certainty in this regard is not necessary for the functioning of a market. Any landowner can cite many areas of uncertainty—for example, the introduction of commercial and industrial uses into a residential area may depress values—yet there is an active market in real estate."[61]

Second, easily defined spectrum borders deliver enormously high social value compared to the cost—and delays—of specifying more complete use rights. When regulators succeed in delegating flexible use rights to a responsible economic agent, specifically an organization constrained by profit maximization, the problems associated with "ill-defined rights" dissipate. Such basic rights are available in the templates used to assign spectrum use rights to mobile carriers in the United States and in many other countries. As discussed below, when these rights are distributed in a manner that avoids

---

59. In the Matter of Unlicensed Operation in the TV Broad. Bands & Additional Spectrum for Unlicensed Devices Below 900 Mhz & in the 3 Ghz Band, Second Report and Order and Memorandum Opinion and Order, 23 FCC Rcd. 16,807 (2008). *See infra* notes 191–94 for a detailed discussion of harmful interference definitions in the white space proceedings between 2002 and 2010.

60. The idea that property rights are costly to establish and, of necessity, are subject to cost-benefit tests, dates to the landmark work by Harold Demsetz, *Toward a Theory of Property Rights*, 57 AM. ECON. REV. 347 (1967). Demsetz's point was that private rights came to replace an "open access" environment when the net benefits of establishing and enforcing private property rights rose above zero. *Id.* The analysis seamlessly transfers to all relevant margins, not just the jump from a situation with ownership rights to one without. *See* Henry E. Smith, *On the Economy of Concepts in Property*, 160 U. PENN. L. REV. 2097, 2115 (2012) [hereinafter Smith, *On the Economy of Concepts in Property*] ("By setting up cheap and rough proxies like boundary crossings, property law can indirectly protect a wide range of largely unspecified interests in use, the details of which are of no particular relevance to those under a duty to respect the right . . . . "); Henry E. Smith, *Property and Property Rules*, 79 N.Y.U. L. REV. 1719, 1725 (2004) (discussing the continuum of uncertainty and risk in the information costs of boundary definition in FRANK H. KNIGHT, RISK, UNCERTAINTY AND PROFIT 19–21, 197–232 (1921)).

61. De Vany et al., *supra* note 38, at 1511.

excessive fragmentation, the ills associated with disputes over harmful interference are almost entirely avoided.

That there exist hard problems in defining private rights to control use of resources does not imply that an administrative allocation of the resource would be superior. To assume such runs smack into the "Nirvana Fallacy," a term coined by Harold Demsetz[62] that was also the key analytical insight of Ronald Coase's famous 1960 essay on social cost.[63] It is true that property rights in land or other resources (such as subsurface minerals, oil pools, fisheries, or patents) are often very complex to define and highly costly to enforce. But the confusion is revealed when it is noted that, in all of these instances, society prefers to rely upon private ownership as the best way to allocate the resource. As Coase has opined, the idea of switching to a "Federal Land Commission" to overcome definitional problems in land rights would (a) not eliminate complexities in distinguishing the appropriate limits imposed upon conflicting uses, and (b) presumably result in far less social welfare:

> No business would have any interest in economizing in the use of its land. Changes in land-use would come about only with great difficulty and would depend to a large extent on land becoming valueless in existing uses. Economic growth in the United States would be slowed by the shortage of land and the problem would no doubt call for Presidential attention. That such would be the consequences of the establishment of a Federal Land Commission is not, I think, open to serious doubt.[64]

Liberal licenses cede de facto spectrum ownership, forcing licensees, through economic incentives common to markets, to rationally weigh gains against losses in choosing among myriad forms of spectrum utilization. This process incorporates the efficient control of harmful interference and far more functional band clearing efforts, such as standards migration and technology development. It prompts the creation of wireless networks via massive sunk, long-term investments, agreements for spectrum sharing with both subscribers and rival network providers, contracts altering initially assigned borders, and mergers. These productive actions result in a reliable process that delivers higher-valued outputs for consumers.

---

62. Harold Demsetz, *Information and Efficiency: Another Viewpoint*, 12 J.L. & ECON. 1, 1–4 (1969).

63. Coase, *supra* note 44.

64. Ronald H. Coase, *Evaluation of Public Policy Relating to Radio and Television Broadcasting: Social and Economic Issues*, 41 LAND ECON. 161, 163 (1965).

Interference disputes in the traditional spectrum allocation system are so destructive not because they deal with inherently complicated matters,[65] which are of equal technical complexity for both governments and firms, but because decision-makers in these disputes do not face strong incentives to avoid controversy and, instead, generate gains from trade.

Incomplete contracts are ubiquitous in commerce because precisely and exhaustively defined agreements covering all possible contingencies are prohibitively expensive.[66] In spectrum, marginal improvements in the delineation of rights, as well as the resolution of disputes over conflicts, may sometimes be warranted, and promising avenues have been outlined.[67] But today, there is no doubt that the most expensive path is found in delaying the distribution of "imperfect" spectrum rights for years or even decades. Sadly, we have wide and deep observational experience with which to gauge this cost. When, for instance, 30 MHz of PCS bandwidth (about 15% of what was then available to mobile carriers) was withheld from the U.S. market in 1995–2005 due to litigation over FCC rules and bankruptcy law in the so-called "PCS C Block fiasco," the estimated loss in social welfare exceeded $10 billion annually.[68]

It has not been entirely missed that economic incentives are part of the solution. Several analysts note the success of liberal licenses[69] and the importance of "economic efficiency" in creating and awarding spectrum use rights.[70] Some have noted the difficulty in defining spectrum use in

65. Whether or not spectrum use rights have changing boundaries is less important than which entities have rights to respond. Probabilistic boundaries of other information resource uses are widespread in other intellectual property forms. *See* Henry E. Smith, *Intellectual Property as Property: Delineating Entitlements to Information*, 116 YALE L.J. 1742, 1822 (2007) ("In both intellectual property and property more generally, exclusion rights—as modified by governance rules—furnish, at some positive cost, modularity to the system of providing inputs and appropriating benefits from assets.").

66. *See* Merrill & Smith, *The Property/Contract Interface*, *supra* note 18.

67. *See Wireless Craze*, *supra* note 30.

68. This is based on econometric estimates of the value of marginal spectrum in mobile services using cross-sectional data from international markets. Thomas W. Hazlett & Roberto E. Muñoz, *A Welfare Analysis of Spectrum Allocation Policies*, 40 RAND J. ON ECON. 424, 436 tbl.5 (2009) (showing annual welfare change in U.S. PCS C-block auctions) [hereinafter *Welfare Analysis*].

69. *See, e.g.*, Gregory L. Rosston & Jeffrey S. Steinberg, *Market-Based Spectrum Policy to Promote the Public Interest*, 50 FED. COMM. L.J. 87 (1997); *SPTFR 2002*, *supra* note 1; Kwerel & Williams, *supra* note 42; Gerald R. Faulhaber, *supra* note 52.

70. *See* MATHESON & MORRIS, *supra* note 56. The debate over whether or not to provide new flexibilities or more permanent rights often convolves the efficiency and distributional effects of proposed change. Here, without taking a position on who should receive the benefit of more flexible or longer-duration rights, we merely say that certain rights are likely to support a more efficient spectrum market than uncertain rights.

unlicensed bands, as with TV Band "white spaces," where economic incentives do not internalize the costs and benefits of "interference" for market agents.[71] What these analysts generally omit is that economic efficiency resulting from rights assignments forms virtually the entire locus of relevant (correctible) policy reform. Treating "economic efficiency" as one factor among many typically results in priority confusion, sending policy analysis in pursuit of time-consuming technical definitions of spectrum boundaries and entirely missing the path to the great social welfare gains that are available.

III. THE TROUBLE WITH EXACTITUDE: EXAMPLES

Examples are both useful and a central feature of the policy literature in this area. Here we focus on those examples that critics commonly give to illustrate how and why FCC definitions of harmful interference need greater clarity, such as the WCS/Satellite Radio and Nextel/Public Safety Radio controversies, and others that are rarely mentioned. These include the problem of harmful interference in the TV Band, by consensus the most costly failure of spectrum policy, and the FCC's attempt (from 2003–2007) to construct an "interference temperature" metric to allow for greater spectrum sharing—an admitted policy failure by the Commission that was intended to bring just the precision to spectrum use rights advocated so frequently today. Later in the Article we will describe other important examples, including those involving Low-Power FM and HD radio and the LightSquared/GPS interference dispute. Each of these episodes illustrates the economic robustness, generated not from regulatory exactitude, but from the distribution of exclusive, flexible rights awarded to economically responsible parties.

A. TV BAND REALLOCATION: PROBLEMS WITH RIGID RIGHTS

In an elaborate[72] and influential discussion[73] of how spectrum use rights can and should be defined in seven dimensions—three more than PCS

71. Goodman, *supra* note 54, at 507.

72. This work derives from the pioneering attempts in the 1960s and 1970s to describe ownership rights in spectrum. *See* De Vany et al., *supra* note 38; COASE, MECKLING & MINASIAN, *supra* note 37, at 1 n.1; Jora Minasian, *Property Rights in Radiation: An Alternative Approach to Radio Frequency Allocation*, 18 J.L. & ECON. 221 (1975). These earlier papers were written prior to liberalization in U.S. (and other) spectrum policy, wherein licenses were created that granted de facto spectrum property rights. Among the most important policy reforms bringing such licenses—now used for cellular networks—into existence were rules delegating licensees discretion over technologies deployed, services supplied, and business models utilized. Since these market changes, some countries have fundamentally revised

license contours and, in our opinion, three too many[74]—Matheson and Morris offer this conclusion on radio interference: "The FCC designs its rules regarding emission masks, transmitter separation criteria, and other licensing rules to prevent harmful interference. If all parties follow license rules, systems usually operate without interference."[75] In fact, these FCC rules are the source of the most costly interference that exists, namely blocked spectrum that is not put to its most productive use. Under this view, there is little or no "interference" on the TV Band when, in fact, the loss to society due to the interference of TV broadcasting rules by the FCC easily exceeds $1 trillion.[76]

The television band constitutes a classic example of the tragedy of the anti-commons,[77] not because technical rules are extraordinarily difficult to construct, but because they have been so easy to construct. By imposing specific engineering and operational limits on spectrum users, conflicts have been managed to a bureaucratic fare-thee-well. Great swaths of bandwidth

their regulatory regimes to more closely mimic property regimes. Four countries where this has happened are New Zealand (1989), Guatemala (1996), El Salvador (1997), and Australia (1997). *See* Thomas W. Hazlett, *Property Rights and Wireless License Values*, 51 J.L & ECON. 563, 567 (2008) [hereinafter Hazlett, *Wireless License Values*].

73. Phil Weiser and Dale Hatfield write: "The final, and most significant, development since the De Vany-led study is a 2005 paper by Robert Matheson. This paper presents the most complete analysis of property rights in radio spectrum as well as the fullest discussion of the practical challenges and limitations of actually employing such rights in the management of the resource." Weiser & Hatfield, *supra* note 17, at 573.

74. *See* MATHESON & MORRIS, *supra* note 56, at 8. The four dimensions that are useful are actually just three: frequency, time, and geographic location (Matheson & Morris define geography in latitude and longitude, yielding the extra dimension). The three incremental dimensions are altitude, azimuth, and elevation angle. Liberal licenses bundle the fragments implied (or defined) by these latter criteria, ceding authority to the licensee for determining how the spaces defined in the other dimensions are best deployed. Defining more divisions than necessary likely incurs higher costs in the administrative allocation of spectrum relative to the alternative—allowing licensees to define use rights where possible. Indeed, holders of liberal licenses routinely pack in additional communications traffic by exploiting differing signal angles (say, with array antenna technology) and the altitude of such signals (as when cell towers are set high, but not too high, above adjacent terrain). *Id.* at 8. However, "[t]hat is not to say that any particular rights holder would wish to subdivide his or her rights along every dimension," yet each additional border increases the number of possible fragments for aggregation in an exponential fashion. *Id.* at 9 (rightly declining to add polarization and/or modulation as additional dimensions to the proposed seven).

75. MATHESON & MORRIS, *supra* note 56, at 31.

76. Thomas W. Hazlett, *Tragedy TV: Rights Fragmentation and the Junk Band Problem*, 53 ARIZ. L. REV. 83, 86 (2011) [hereinafter *Tragedy TV*].

77. Lee Anne Fennell, *Commons, Anticommons, Semicommons*, *in* RESEARCH HANDBOOK ON THE ECONOMICS OF PROPERTY LAW (Kenneth Ayotte & Henry E. Smith, eds., Edward Elgar, 2009), *available at* http://www.law.uchicago.edu/files/files/457-261.pdf; *see also id.* at 11 (describing anticommons as "an assembly problem, nothing more and nothing less").

have been left idle, and myriad new services have been thwarted, all to protect existing transmissions according to a plan imposed in the TV Allocation Table of 1952. The proximate cause of this non-market failure has been exact, rigid use rights limitations that rest too few utilization choices with competitive markets and too many with regulators who fail to properly weigh economic trade-offs.[78]

The great technological upgrade during this six-decade policy rollout was the digital TV transition, officially initiated in 1987 and completed in June 2009 when the last full-power analog TV stations were switched off.[79] But in just thirteen years, cellular operators transitioned analog mobile phone users to a fully digital system without mandates and without massive spectrum set-asides, and away from a system that consumed most of the spectrum allocated to the service. Michael Heller asks, and answers, the key legal question: "What's the difference between cell and television performance? Private versus anticommons ownership of the underlying spectrum—not technological limits."[80]

B. HD RADIO: BUNDLING RIGHTS

Yet, without controversy, vast vacant space was discovered in the FM band and a large number of new broadcasting rights were issued. In 2002, the

78. For a general analysis of "non-market failure," see CHARLES WOLF, JR., MARKETS OR GOVERNMENTS?: CHOOSING BETWEEN IMPERFECT ALTERNATIVES (MIT Press rev. ed. 1993). "It does not follow that whenever laissez faire falls short government interference is expedient; since the inevitable drawbacks of the latter may, in any particular case, be worse than the shortcomings of private enterprise." HENRY SIDGWICK, PRINCIPLES OF POLITICAL ECONOMY 414 (Macmillan 1883), cited in Charles Wolf, Jr., *A Theory of Nonmarket Failure: Framework for Implementation Analysis*, 22 J.L. & ECON. 107, 107 n.1 (1979); *see also id.* at 112 (citing ROBERT BACON & WALTER ELTIS, BRITAIN'S ECONOMIC PROBLEM: TOO FEW PRODUCERS (Macmillan 1976)).

Just as the absence of particular markets accounts for market failure, so nonmarket failures are due to the absence of nonmarket mechanisms for reconciling calculations by decision makers of their private and organizational costs and benefits with total costs and benefits. Nor, for reasons we will suggest, are prospects for invention of suitably compensatory nonmarket mechanisms to avoid nonmarket failure notably brighter than for creating suitable markets where their absence leads to market failures.

79. FCC, *Frequently Asked Questions*, DTV.GOV, http://dtv.gov/consumercorner.html ("In 1996, Congress authorized the distribution of an additional broadcast channel to each broadcast TV station so that they could use it for digital broadcasting while simultaneously continuing their analog broadcast channel. Later, Congress mandated June 12, 2009 (extended from February 17, 2009) as the last day for full-power television stations in the U.S. to broadcast in analog . . . .").

80. HELLER, *supra* note 16, at 96.

FCC authorized hybrid digital ("HD") Radio.[81] The new rules permitted each of the existing 8,840 full-power FM radio stations and 4,700 AM radio stations to adopt a new format that, while continuing to transmit a primary analog signal, broadcasted two new digital signals.[82] This yielded an immediate increase in potential FM broadcasts of nearly 17,680, a 200% increase from 8,840 existing full-power FM stations. When HD receivers become more widespread, FM stations may select an all-digital broadcasting format that permits the sending of seven signals per FM channel, three full-power and four low-power.[83] Hence, the FCC's 2002 authorization for HD Radio cleared a path for another 54,000 FM broadcasts.[84] In 2005, 1,272 HD stations (195 AM and 1,077 FM) were broadcasting with an in-band on-channel ("IBOC") system and 700 FM stations had special temporary authority for multicasting with 2,000 more in the pipeline.[85] In early 2012, more than 2,100 HD radio stations were broadcasting, and some 3 million HD receivers had been sold.[86] There were more than 650 stations in the top 100 markets, and advertising sales on these stations was projected to exceed $110 million in 2011.[87]

The HD authorization sailed through the FCC without controversy.[88] That was not because the new stations do not create any interference. In

81. *See* In the Matter of Digital Audio Broadcasting Systems and their Impact on the Terrestrial Radio Broadcast Service, First Report and Order, 17 FCC Rcd. 19,990, 19,995–96 (2002) [hereinafter 2002 HD Radio R&O], *available at* http://fjallfoss.fcc.gov/edocs_public/attachmatch/FCC-02-286A1.pdf.

82. *Id.* at 19,999 (4,700 AM stations); In the Matter of Digital Audio Broadcasting Systems and their Impact on the Terrestrial Radio Broadcast Service, Second Report and Order First Order on Reconsideration and Second Further Notice of Proposed Rulemaking, 22 FCC Rcd. 10,344, 10,349 ¶ 11 n.17 (2007) [hereinafter 2007 HD Radio R&O], *available at* http://apps.fcc.gov/ecfs/document/view?id=6520026787 (noting that in 2005, there were 10,973 commercial radio stations, 2,625 FM educational radio stations, and of the commercial stations, 6,215 were FM stations and 4,758 were AM stations).

83. In the Matter of Review of the Emergency Alert System, 20 FCC Rcd. 18,625, 18,637 (2005) ("Radio stations will eventually convert to all-digital modes of operation.") (addressing emergency alert systems for DTV, DAB, digital cable, DBS, and SDARS).

84. FM stations have maximum ERPs of 100,000 watts (grandfathered or waivered cases), 50,000 watts, or the majority with average 6,000 watts of ERP. 2002 HD Radio R&O, *supra* note 81 (6,000 watt ERP Class A FM station). Low-power FM stations are sixty times smaller at 100 watts ERP.

85. 2007 HD Radio R&O, *supra* note 82, at 10,349.

86. *What is HD Radio Broadcasting?*, IBIQUITY DIGITAL, http://www.ibiquity.com/hd_radio (last visited Jan. 12, 2013).

87. *HD Radio Alliance Announces 2011 Marketing Plans*, HD RADIO (Nov. 30, 2010), http://www.hdradio.com/press-room/hd-radio-alliance-announces-2011-marketing-plans.

88. *See* TaNoah Morgan, *Digital Radio Approved by FCC*, BALTIMORE SUN, Oct. 11, 2002, http://articles.baltimoresun.com/2002-10-11/business/0210110010_1_digital-radio-hd-radio-broadcasters ("The Federal Communications Commission gave its blessing

packing thousands of new full-power transmissions into the FM band, spillovers are technically far deeper an issue than with the insertion of tiny 100W emissions, which generated significant controversy in the Low-Power FM (LPFM) docket.[89] Much greater electromagnetic levels of "interference" for HD Radio were approved than for LPFM, with the support of the radio industry.[90]

Spillovers were thus more economically managed in HD Radio than in the case of LPFM.[91] This coordination of HD Radio interference was due to the form in which the spectrum rights were issued and the transaction costs surrounding the resulting economic organization.[92] In short, the tragedy of the commons[93] that blocked fuller deployment of the FM band under the regulatory approach employed in LPFM evaporated when the Commission pursued an alternative path, as in the case of HD Radio. A key distinction

yesterday to a digital radio technology for local broadcasters that promises highly improved sound for consumers and new revenue streams for broadcasters.").

89. *Cf.* 2002 HD Radio R&O, *supra* note 81, at 19,995 ("[M]inimizing interference to stations on first- and, to a lesser extent, second-adjacent channels poses the most serious analog compatibility challenge.") (citation omitted). Some noted interference concerns for "a limited number of listeners may perceive an impact outside of the protected contour under certain conditions." *Id.* Interested parties found a way to agree, "including all of the broadcasters that address the issue . . . that this is a reasonable tradeoff." *Id.* (footnote omitted).

90. 2002 HD Radio R&O, *supra* note 81, at 20,002 ("According to iBiquity, the estimated costs of implementing its hybrid IBOC system range from $30,000 to $200,000, with an average cost of $75,000. Conversion costs vary depending on the age and other characteristics of a station's transmitter plant and studio equipment.") (footnote omitted).

91. *See* In the Matter of Econ. Impact of Low-Power FM Stations on Commercial FM Radio: Report to Cong. Pursuant to Section 8 of the Local Cmty. Radio Act of 2010, Report, 27 F.C.C.R. 3 (2012) [hereinafter 2012 LPFM Report], *available at* http://transition.fcc.gov/Daily_Releases/Daily_Business/2012/db0105/DA-12-2A1.pdf. An act of Congress was required after a decade of policy deliberation. *See id.*; LOCAL COMMUNITY RADIO ACT OF 2010, § 8, PUB. L. NO. 111-371, 124 STAT. 4072 (2011), following LPFM interference definitions starting with the 2000 LPFM Order. 2012 LPFM Report, *supra*, at 7 ¶ 14 n.20 (citing In the Matter of Creation of Low Power Radio Service, Report & Order, 15 FCC Rcd. 2205 (2000)).

92. Stations have increased interference between digital and analog receivers by increasing digital power in 2010 in symmetric operation in sidebands, with requests currently pending in 2012 for asymmetric interference due to new technology. *See* In the Matter of Digital Audio Broad. Sys. & Their Impact on the Terrestrial Radio Broad. Serv., Order, 25 FCC Rcd. 1182 (2010), *available at* http://apps.fcc.gov/ecfs/document/view?id=7020409846.

93. For an overview on the "tragedy of the commons," see Hardin, *supra* note 12, at 1243; Thráinn Eggertsson, *Open Access Versus Common Property*, *in* PROPERTY RIGHTS: COOPERATION, CONFLICT AND LAW 75 (Terry L. Anderson & Fred S. McChesney, eds., 2002); Heller, *The Tragedy of the Anticommons: Property in the Transition from Marx to Markets*, 111 HARV. L. REV. 621 (1998); Fennell, *Common Interest Tragedies*, 98 NW. L. REV. 907 (2004).

was that LPFM awarded new rights to *entrants*, and HD Radio implemented software upgrades and asymmetric sideband innovations for *incumbents*.[94] There were two forces at work to determine this bifurcated outcome, with LPFM reflecting deep structural inefficiencies in spectrum allocation and with HD Radio reflecting important efficiency considerations in the creation and distribution of property rights.

The moral is not that new entry is impossible in the absence of industry capture, or even that regulatory disputes over harmful interference have their roots in financial interest rather than in "technical" spillovers. The lesson here is that the *manner* in which spectrum rights are awarded—the legal rights yielding economic incentives—decisively determines whether "technical" opportunities by way of innovative combinations of receivers, band plans, and software will be found or lost. The FCC's efforts to craft superior radio contours are a sideshow. When the FCC attempted to define "white spaces" to accommodate new LPFM broadcasting on the FM dial without the cooperation of full-power FM stations, it effectively found nothing. When it gave incentives to FM stations to find the iBiquity HD "white spaces," suddenly thousands of new opportunities were discovered.

Another key aspect of the HD Radio spectrum allocation, however, is rarely noted. In permitting incumbent licensees to place three (or seven) broadcasts in the frequency space (200 KHz) where only one broadcast had previously been authorized, the FCC bundled new rights with an incumbent licensee's existing rights.[95] By expanding rights bundles, rather than inserting new rights (and rights holders) immediately adjacent to existing broadcasters, the FCC avoided the fragmentation of new, contentious borders. There will still be borders, technically speaking, and spillovers that cross them. But with both of the rival broadcasts owned by the same licensee, the costs and benefits of emissions are internalized.

FM stations are thus able to increase their spectrum usage, balancing new stations with existing broadcasts, by upgrading to digital technology. This upgrade was mandated as part of the authorization and is a product of traditional FCC regulation, which specifies exactly how licensees use

94. Comments of iBiquity Digital Corp., In the Matter of Digital Audio Broadcasting Systems And Their Impact on the Terrestrial Radio Broadcast Service, Attachment A, at 4, MM Docket No. 99-325 (Dec. 19, 2011), *available at* http://apps.fcc.gov/ecfs/document/view?id=7021751178 ("HD Radio software versions 4.4.x and above allow for independent, asymmetric sideband control by implementing a new peak-to-average power ratio reduction algorithm.").

95. *See supra* note 83.

airwaves.[96] But this upgrade does not alter the underlying efficiency of the bundled nature of the new rights awarded. In fact, efficiencies of greater magnitude are observed when liberal licenses—with no technology or service mandates—are awarded.[97]

Far more broadly, it is a principle in property law that *complementary resource rights* be defined together. For example, the landowner has both broad control of her real estate and the right to exclude those not granted the right to encroach. But when airplanes were invented and commercial flights began, the question arose: did each landowner have a claim to exclude them? In *United States v. Causby*, the Court found that the right to own real property did not include air routes some 30,000 feet overhead.[98] There was little complementarity between the planes (or the airspaces they used) and the land below. Moreover, tying ownership of the high sky to the land would have created significant, and likely prohibitive, transaction costs. By deleting these rights from the land ownership bundle, those transaction costs were avoided. As with HD Radio, but with the opposite result (splitting rights rather than bundling them), the transactionally efficient path was found. Such divergent results are in direct accord with Demsetz's work on the costs and benefits of rights definition.[99]

C. LICENSED PCS VERSUS UNLICENSED PCS: ADMINISTRATIVE RULES VERSUS MARKET MECHANISMS

The allocation of Personal Communications Services ("PCS"), which stretched (officially) from 1989 to 1995, authorized CMRS licenses (120 MHz) and an unlicensed PCS ("U-PCS") band (30 MHz).[100] The licensed bandwidth has been intensely utilized in mobile phone networks, and is responsible for a significant fraction of the more than $200 billion in annual consumer surplus delivered by mobile services.[101] The U-PCS allocation has

96. The HD technology was not developed by the FCC, but by iBiquity, a private company that has allied with radio broadcasters to produce HD Radio. Radio stations petitioned for the HD authorization and recommended that the FCC implement reforms that included the iBiquity-HD technology upgrade. *See* 2002 HD Radio R&O, *supra* note 81, at 19,992 ¶ 6 ("The NAB concurs, stating simply, '[i]t works; it's ready' ") (from comments of the NAB on Feb. 19, 2002).

97. *See* Thomas W. Hazlett & Evan Leo, *The Case for Liberal Spectrum Licenses: A Technical and Economic Perspective*, 26 BERKELEY TECH. L.J. 1037 (2011).

98. 328 U.S. 256 (1946).

99. *See supra* note 43 and accompanying text.

100. NBP 2010, *supra* note 3, at 79 fig.5-C; *see also infra* notes 103–04.

101. *See* Hazlett, Muñoz & Avanzini, *supra* note 6.

been notably unsuccessful, with most of the bandwidth used lightly if at all.[102] Recent FCC proceedings have either reallocated the U-PCS spectrum or reconfigured rules in an attempt to induce more device deployment.[103]

A major obstacle for the entire PCS band was the presence of some 4,500 incumbent microwave licensees. These operators consumed relatively little bandwidth but were adamantly opposed to relocating (by either using new frequencies or switching operations to alternative communication modes, such as fiber or satellite links).[104] A years-long political standoff froze the U.S. PCS allocation even as E.U. countries were, between 1989 and 1992, allocating 2G licenses (equivalent to PCS). What broke the deadlock was a compromise in the form of "overlay" licenses.[105] New PCS licenses would be issued as overlays, meaning that incumbent licensees would be grandfathered.[106] Once the new licenses had been auctioned and assigned, these overlay licensees could then bargain with the incumbents to release their spectrum by moving to an alternative option—induced by payments from the overlay licensees. Supported by an FCC decision to impose arbitration procedures (to determine the costs of relocation, for which the

102. U-PCS operations were authorized by the FCC in 2004 with spectrum etiquette standards. In the Matter of Amendment of Part 15 of the Commission's Rules Regarding Unlicensed Pers. Communications Serv. Devices in the 1920–1930 MHz Band, Notice of Proposed Rulemaking, 25 FCC Rcd. 5118, 5119–20 ¶ 4 (2010) [hereinafter 2004 U-PCS NPRM], *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-10-77A1.pdf (where "listen-before-transmit" protocols involved channel monitoring between unlicensed devices). The Commission provided additional technical flexibility in 2004 to promote greater use of the spectrum, *id.* at 5120–21 ¶ 5, and again in the 2012 U-PCS R&O, *infra* note 103. The band suffered from underuse, precipitating requests to modify the rules to allow for "more devices to access usable channels . . . currently [ ] restricted from use under the existing 50 dB above thermal noise threshold, but that are actually acceptable for use." 2004 U-PCS NPRM at 5123 ¶ 12.

103. In the Matter of Amendment of Part 15 of the Commission's Rules Regarding Unlicensed Pers. Communications Serv. Devices in the 1920–1930 MHz Band, Report & Order, 27 FCC Rcd. 3645 (2012) [hereinafter 2012 U-PCS R&O], *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-12-33A1.pdf.

104. 2004 U-PCS NPRM, *supra* note 102, at 5126–27 ¶ 18 (describing the formation of a coalition in 1993 of a Unlicensed PCS Ad Hoc Committee for 2 GHz Microwave Transition and Management (UTAM, Inc.) to manage the fixed microwave incumbent transition); *see also* In the Matter of Amendment of the Commission's Rules to Establish New Personal Communications Services, Second Report & Order, 8 FCC Rcd. 7700, 7775–78 (1993) [hereinafter 1993 Broadband PCS Second R&O], *modified on recon.*, 9 FCC Rcd. 4957 (1994), *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-94-144A1.pdf.

105. 1993 Broadband PCS Second R&O, *supra* note 104; *see* Cramton et al., *infra* note 122, at 664–65.

106. 1993 Broadband PCS Second R&O, *supra* note 104; *see* Cramton et al., *infra* note 122, at 664–65.

overlay licensee was liable) and time limits for negotiations, the set-up worked to clear licensed PCS bands—an effective approach to mitigating harmful interference in that PCS licensees would not pay moving costs were these costs to exceed the benefits of microwave relocation.[107]

U-PCS had a more difficult time clearing 1,100 incumbents to mitigate interference. Unlike the licensed PCS bands, no entity internalized both the benefits and costs of band clearing. This created a problem anticipated by the FCC, which set up rules to deal with it in its initial U-PCS Order.[108] First, it mandated that devices (such as cordless phones) used in the band employ a "listen before talk" protocol.[109] Restricting access to vacant channels presumably prevents interference with existing transmitters. Second, a frequency coordinator, Unlicensed Transition and Management ("UTAM"), was assigned the task of monitoring conflicts and relocating incumbents.[110] This organization was supported by a fee on U-PCS devices, originally set by the FCC at $20 per unit sold. The purpose was to mimic what a spectrum owner would do, paying conflicting users to relocate in a situation where the benefits of clearing U-PCS spectrum would not accrue to any particular device vendor (all would potentially realize the gain) or licensee (there was none).[111]

While incumbents were eventually cleared from the U-PCS band in April 2005, the process in licensed PCS spectrum ("L-PCS") proceeded far more expeditiously.[112] Moreover, the use of tools used to mitigate interference

107. *See, e.g.*, Wireless Telecommunications Bureau Announces Commencement of the Voluntary Negotiation Period for 2 GHz Microwave Incumbents Operating in the Broadband PCS "C" Block, DA 96-838 (May 24, 1996), http://fjallfoss.fcc.gov/edocs_public/attachmatch/DA-96-838A1.pdf.

108. In the Matter of Amendment of the Commission's Rules to Establish New Personal Communications Services, Fourth Memorandum Opinion and Order, 10 FCC Rcd. 7955 (1995) [hereinafter 1995 Broadband PCS Fourth MO&O], *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-95-167A1.pdf.

109. *See* 2004 U-PCS NPRM, *supra* note 102, at 5119–20 ¶ 4.

110. 1995 Broadband PCS Fourth MO&O, *supra* note 108, at 7955 ¶ 1.

111. *Id.* at 7957 ¶ 9.

112. There were severe problems in deploying some of the licensed PCS spectrum, but they were not associated with the transaction costs of band clearing. The A and B PCS licenses, allocated 30 MHz each, were auctioned in 1995 and the spectrum was productively deployed soon thereafter. The assignment of D and E licenses (10 MHz each) took place following a 1996 FCC auction, with similarly smooth deployment. However, the C (30 MHz) and F (10 MHz) licenses, auctioned in 1996 with "designated entity" ("DE") bidding preferences extended to small businesses and rural telephone carriers met with disaster. DEs received long-term loans at Treasury bond interest rates to buy licenses, a risk shifting the FCC came to regret. The largest DEs overbid for licenses, declared bankruptcy, and were then protected by bankruptcy law from having to return their FCC licenses. Indeed, they received substantial price reductions after bankruptcy declarations. The FCC objected and

proved far more onerous in U-PCS than in L-PCS.[113] While there are other important factors at work in this natural experiment (pitting licensed against unlicensed spectrum allocations), the *technical* nature of the interference faced from microwave incumbents in either case was *identical*. Administrative rules for interference control specified in 2004 and modified in 2012, in the case of U-PCS, were tested against market mechanisms deployed in the case of L-PCS through spectrum auctions and liberal licenses. By delegating broad, exclusive authority over how to use designated spectrum spaces to licensees, the FCC efficiently resolved an "interference dispute." Hold-ups were overcome while onerous technology restrictions were avoided. The resulting productivity—at least $40 billion annually[114]—illustrates the principle: border issues are often best dealt with not by regulating receivers or transmitters, but by issuing rights that obviate the need for such complicated regulatory tasks.

D. WCS/SATELLITE RADIO: THE BENEFITS OF MERGER

The dispute between Wireless Communications Service ("WCS") licensees and Satellite Digital Audio Radio Service ("SDARS") licenses over interference rules is often cited as an example of interference disputes that require administrative decree. The WCS/SDARS border has made, and continues to make, the WCS band unusable for high valued products such as mobile voice and data services.[115] Allocated 25 MHz in the 2.3 GHz band,

took the case to the U.S. Supreme Court, where it lost. Deals were then struck between the bankrupt parties and the FCC, with the Commission ending up with a large number of the C and F block licenses. These were finally re-auctioned in 2005. *See* Thomas W. Hazlett & Babette E.L. Boliek, *Use of Designated Entity Preferences in Assigning Wireless Licenses*, 51 FED. COMM. L.J. 639 (1999); FCC v. NextWave Personal Commc'ns., Inc., 537 U.S. 293 (2003) (holding that the FCC cannot "revoke a license held by a bankruptcy debtor upon debtor's failure to make timely payments"); HAROLD W. FURCHTGOTT-ROTH, A TOUGH ACT TO FOLLOW?: THE TELECOMMUNICATIONS ACT OF 1996 AND THE SEPARATION OF POWERS FAILURE 126–27 (AEI Press, 2006).

113. *See In Re* Amendment of Commission's Rules to Establish New Pers. Communications Services, Narrowband PCS, Second Report & Order & Second Further Notice of Proposed Rule Making, 15 FCC Rcd. 10,456, 10,463 ¶¶ 11, 13 (2000); *id.* at 10,464 ¶ 15 (declining to create additional licenses, but allowing for aggregation of licenses, and supporting larger licensing areas for narrowband PCS).

114. *Welfare Analysis*, *supra* note 68, at 433. Hazlett & Muñoz estimated a marginal social value of a 60 MHz license equal to approximately $10 billion in 2003. *Id.* at 434. The infra-marginal PCS allocation, allocated 120 MHz, would likely be worth more per MHz (i.e., exceed $40 billion in annual welfare gains). NBP 2010, *supra* note 3, at 85 fig.5-F.

115. The FCC adopted an order to modify rules on the contentious WCS/SDARS band to allow for LTE Mobile Broadband. *See* In the Matter of Amendment of Part 27 of the Comm'n's Rules to Govern the Operation of Wireless Communications Services in the 2.3 Ghz Band, Order on Reconsideration, 27 FCC Rcd. 13,651 (2012) [hereinafter 2012 WCS/SDARS Order on Reconsideration], *available at* http://transition.fcc.gov/Daily_

WCS airwaves could potentially generate several billions annually in consumer surplus.[116]

The proximate cause of the spectrum border dispute is that satellite radio signals arrive at the subscriber's radio relatively weakly (i.e., with low power), given the long distances they travel in geosynchronous orbit around the equator. The satellite radio signals are susceptible to very low levels of radio emissions spilling from adjacent bands—and more so when those levels are raised due to the use of millions of mobile receivers such as handsets. This is because mobile use of both those WCS devices and SDARS receivers would tend to put many of the latter in close proximity to the former in unpredictable ways. Perhaps better, more technically sophisticated use rights for the respective services would solve the problem.[117] This point is almost irrelevant without a new structure for the regulatory system, which for fifteen years has failed to adopt whatever new technical rules are advocated now,[118] and ignores the obvious market-based solution that was rejected by the FCC: merger.

In 2005, XM Satellite Radio, an SDARS licensee, offered to pay $198 million to buy the WCS licenses.[119] The combination would have eliminated the WCS/SDARS border dispute by eliminating the border through economic alignment. Indeed, the most widespread and effective solution to technical definition issues is to sidestep them by allowing integration of

Releases/Daily_Business/2012/db1023/FCC-12-130A1.pdf. For descriptions of LTE and WiMax uses on the band, see *id.* at 13,660–61 ¶ 18 n.57; *id.* at 13,673–74 ¶ 51.

116. The 2.3 GHz band is close, and similar in propagation characteristics, to the PCS band (1.9 GHz) and the AWS band (1.7/2.1 GHz). Frequencies in these bands are commonly used to provide mobile voice and data services, including 3G and 4G high-speed data connections. This suggests that the WCS allocation could, under alternative regulatory rules, host traffic about as valuable as seen in cellular markets—where an incremental 30 MHz was found, in 2003, to add over $10 billion in social value to the U.S. economy. *Welfare Analysis*, *supra* note 68.

117. Consider the implications of the 2012 order, where AT&T and Sirius XM agreed upon ground power level targets, where the FCC could not broker a resolution for many years. 2012 WCS/SDARS Order on Reconsideration, *supra* note 115, at 13,663–64 ¶¶ 22–26.

118. *See* 2012 WCS/SDARS Order on Reconsideration, *supra* note 115, at 13,655–56 ¶ 7 (discussing the procedural history beginning in 1997). Recall that the 30 MHz on the WCS/SDARS band was heralded for the WiMAX innovation in 2010, with the need for administrative action in 2012 to specify LTE. *See* In the Matter of Amendment of Part 27 of the Commissions Rules to Govern the Operation of Wireless Communications Services in the 2.3 Ghz Band, Report & Order & Second Report & Order, 25 FCC Rcd. 11,710, 11,718 ¶ 15 (2010), *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-10-82A1.pdf.

119. *XM to Buy WCS Wireless for Nearly $200 Million*, MEDIA POST (July 14, 2005), http://www.mediapost.com/publications/article/32096/xm-to-buy-wcs-wireless-for-nearly-200-million.html.

ownership.[120] The FCC blocked the merger between XM Radio and WCS, bending to pressure by satellite radio rivals (terrestrial radio stations) to deny the evidently pro-competitive transaction.[121] Importantly, the efficient solution to this particular interference dispute was to integrate ownership of the conflicting licenses, a remedy that market forces sought to implement and that regulators blocked. That leading analyses of how to craft policies dealing with radio interference routinely ignore the importance of merger is emblematic of the confusion in the discussion.

E. NEXTEL/PUBLIC SAFETY RADIO: ELIMINATING BORDERS

The long-running dispute between Nextel and public safety radio users, such as police and fire departments, is almost universally cited in the interference literature.[122] In brief, the problems at issue came up when little used dispatch licenses, known as Specialized Mobile Radio ("SMR") licenses, allocated in this 800 MHz band, were relaxed to permit the use of digital services to supply mobile phone calls to the public. In going from "pizza delivery" radio[123] to a full-fledged competitor in cellular, the SMR licenses

120. This is a subtle but far-reaching point. A very general efficiency in the creation and distribution of property rights is to award such rights, initially, such that fragmentation—and associated issues of border definition and enforcement—does not preempt efficient resource uses. A leading goal of legal rules or regulatory policy, then, must be to allow or even enable efficient rights aggregation so that optimally sized bundles of ownership rights are not pre-empted by transactions costs. Importantly, legal processes that overly divide and separate complementary rights here impose such transaction costs implicitly. *See* HAROLD DEMSETZ, *Reinterpreting the Externality Problem*, *in* FROM ECONOMIC MAN TO ECONOMIC SYSTEM: ESSAYS ON HUMAN BEHAVIOR AND THE INSTITUTIONS OF CAPITALISM 112–13 (2008). ("Legal error has caused the problem, not positive transaction cost. There is no inefficiency in the way the market accommodates to the court's mistake.") (emphasis omitted). *See also* HELLER, *supra* note 16, at 104 ("Given the forced nature of the exchange, markets couldn't price network fragments."); *id.* at 77 ("The crucial point is that the emerging structure of drug discovery clashes more and more with old-fashioned patent law and competition policy.").

121. *XM Satellite, WCS Wireless Abandon Merger*, FIERCE WIRELESS (May 22, 2006), http://www.fiercewireless.com/story/xm-satellite-wcs-wireless-abandon-merger/2006-05-23 ("XM Satellite and WCS Wireless abandoned their agreement that called for XM to buy WCS and its wireless spectrum licenses because they were unable to receive regulatory approvals for the deal."). Since then, Sirius Satellite Radio and XM Satellite have merged to form Sirius XM Radio Inc. SIRIUS and XM Complete Merger, Sirius XM Radio (July 29, 2008), http://investor.sirius.com/ReleaseDetail.cfm?ReleaseID=324858.

122. *See, e.g.*, Dale Hatfield, *Radio Regulation Summit: Defining Out-of-Band Operating Rules*, Silicon Flatirons Center for Law, Technology, and Entrepreneurs, Sept. 8–9, 2009, *available at* http://www.silicon-flatirons.org/documents/misc/OOBSummit/SFC%20Interference%20Summit%20-%20September%2009wo.ppt; Peter Cramton, Evan Kwerel & John Williams, *Efficient Relocation of Spectrum Incumbents*, 41 J.L. & ECON. 647 (1998).

123. The SMR licenses had been used for dispatch calls such as those made for taxi pick-ups and pizza deliveries.

were transformed from a wireless backwater into a high-productive addition to the emerging Information Economy.[124] At the same time, the millions of mobile handsets using the SMR frequencies were generating more noise, and radio emissions were much more likely to spill over into adjacent frequencies.[125]

Many public safety agencies used those adjacent bands for their radio communications. As has been well documented by the FCC, these users complained that vital transmissions were being endangered. Regulators took such complaints, which implicated life or death outcomes, seriously.[126] For many years, however, the dangerous situation continued.[127] Finally, the FCC embraced a Nextel-proposed "spectrum swap."[128] Nextel would (a) give up some of its licenses to use bands next to fire and police bands; (b) pay for new equipment like radios and base stations so public safety users could begin using Nextel's abandoned SMR bands; (c) receive new FCC licenses allowing them to use an altogether different frequency location (10 MHz at

124. *See* HELLER, *supra* note 16, at 93. For an account of entrepreneur Morgan O'Brien's successful efforts to turn under-used spectrum into wireless gold, see JAMES B. MURRAY, JR., WIRELESS NATION: THE FRENZIED LAUNCH OF THE CELLULAR REVOLUTION IN AMERICA 251–66 (2001).

125. In the Matter of Improving Pub. Safety Communications in the 800 Mhz Band, Report & Order, Fifth Report & Order, Fourth Memorandum Opinion & Order, and Order19 FCC Rcd. 14,969, 14,983 ¶ 21 (2004) [hereinafter 800 MHz R&O], *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-04-168A1.pdf (showing a diagram of the multiparty band).

126. 800 MHz R&O, *supra* note 125, at 14,975–76 ¶ 7 ("These considerations require that we take the most effective actions, in the short-term and long-term, to promote robust and reliable public safety communications in the 800 MHz band to ensure the safety of life and property.").

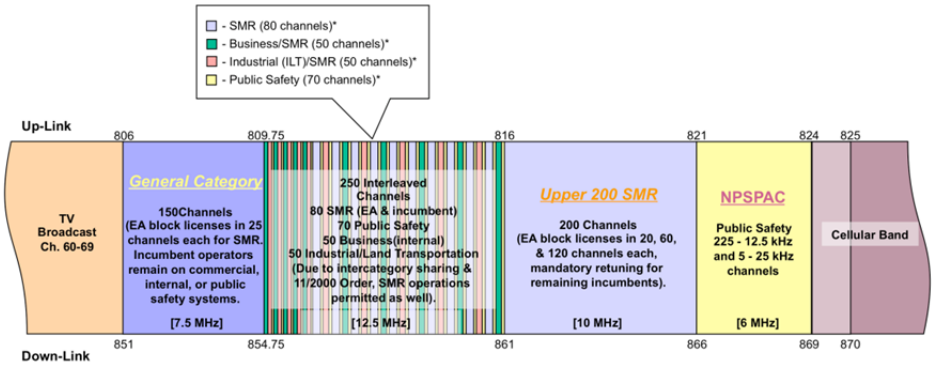
127. *Id.* at 14,976 ¶¶ 8–9 (citing the ongoing problem of interference to 800 MHz public safety communications systems, which the FCC could not resolve by either band reconfiguration or case-by-case "technical fixes").

128. *Id.* at 14,987–88 ¶ 31; *id.* at 14,989–94 ¶ 35–42. The Consensus Plan reordered the Nextel-Public Safety border. For a detailed timeline, see *id.* at 15,002–10 ¶ 61. The Notice of Proposed Rulemaking began in 2002, in *In Re* Improving Pub. Safety Communications in 800 Mhz Band, Notice of Proposed Rule Making, 17 F.C.C.R. 4873, 4882 ¶ 16 (2002). Private solutions for "voluntary technical changes to prevent or reduce interference" of the multidimensionally inefficient borders were proposed in 2000 but gridlocked with regulatory rights of interference. 800 MHz R&O, *supra* note 125, at 14,979–80 ¶¶ 14–15 ("The Consensus Parties have proposed a band reconfiguration plan that would move ESMR systems—most notably Nextel—to the upper portion of the 800 MHz band, move all public safety and "high site" operators to the lower portion of the band, and make additional spectrum in the band available for public safety use."); *id.* at 14,982–83 ¶ 20 ("The method of interference abatement we adopt herein leaves to the involved parties—and not the Commission—the choice of how best to ensure that their systems do not cause unacceptable interference.").

1.9 GHz); and (d) pay $4.8 billion for the new award, less the relocation costs of $850 million or more, which Nextel would pay for public safety radios.[129]

The common conclusions taken from this episode are (1) that border definitions are difficult, which is true; and (2) that more careful technical specification of spectrum rights is needed to deal with this problem, which is false. The lack of specificity was neither the true cause of the problem nor the answer that was eventually implemented. The underlying problem was that the FCC spectrum allocation scheme for SMR was a model of regulatory mischievousness. The band plan featured small slices of bandwidth, channels to be assigned to different licenses, and licenses to be assigned to different users. These narrow channels were "interleaved," the opposite of the solution needed and later adopted, which featured contiguous blocks of spectrum.[130]

Figure 1: FCC 800 MHz SMR/Public Safety Band: 2001[131]



129. 800 MHz R&O, *supra* note 128, at 14,987–88 ¶¶ 29, 31.

130. *See* FCC, *SMR and Cellular Frequencies Presentation*, http://wireless.fcc.gov/releases/011121-exibit.ppt [hereinafter *SMR and Cellular Frequencies Presentation*]; NEXTEL COMMUNICATIONS, INC., WHITE PAPER, PROMOTING PUBLIC SAFETY COMMUNICATIONS: REALIGNING THE 800 MHZ LAND MOBILE RADIO BAND TO RECTIFY COMMERCIAL MOBILE RADIO-PUBLIC SAFETY INTERFERENCE AND ALLOCATE ADDITIONAL SPECTRUM TO MEET CRITICAL PUBLIC SAFETY NEEDS 7 (2001), *available at* http://wireless.fcc.gov/releases/011121-whitepaper_final.pdf; Letter from Nextel Communications, Inc., to FCC (Nov. 21, 2001), *available at* http://wireless.fcc.gov/releases/011121-letter.txt. In the public safety band, interleaving occurred at the license layer. Interleaving of spectrum can also occur on a time, frequency, or geographic basis, where modern (code division) CDMA and (frequency division) OFDMA modulation standards are embedded within mobile hardware.

131. *SMR and Cellular Frequencies Presentation*, *supra* note 130 at 6; *Nextel 800 MHz Interference Plan*, DISPATCH MAGAZINE, http://www.911dispatch.com/info/800_transition/nextel_slides.html [hereinafter *Nextel Interference Plan*] (as presented in Nextel's slides in FCC presentation).

A picture is worth a thousand words or, at least, 6.25 MHz. Notice how this modest block of spectrum was split into 250 separate channels in the original SMR band plan, depicted in Figure 1. Each channel was then assigned to one license, and licenses were distributed to different licensees. In bandwidth that would constitute less than one license elsewhere—cellular licenses are allocated 25 MHz each—literally hundreds of borders were created by the FCC rights creation process.[132] This dictated needless costs in social coordination, which could only be undone by a process of license aggregation.

Nextel pursued license aggregation, advancing a plan for FCC spectrum reorganization and lobbying public safety interests to support it, as seen in Figure 2, *infra*. The general approach of aggregating licenses was nothing new for Nextel. Indeed, the Nextel network had been stitched together by the acquisition of over 40,000 SMR licenses purchased in secondary markets.[133] This strategy enabled Nextel, a national carrier, to emerge to compete with the cellular duopoly.[134] It created a resource so valuable that Nextel ultimately served 15 million subscribers and was sold to Sprint for $35 billion in 2005.[135] However, the process of license aggregation stopped short when Nextel targeted licenses controlled by public safety organizations. These licenses were not owned by profit-seeking enterprises, so trades were problematic, if not illegal. Moreover, the balkanized nature of the rights, strewn throughout tens of thousands of local agencies, frustrated collective action.

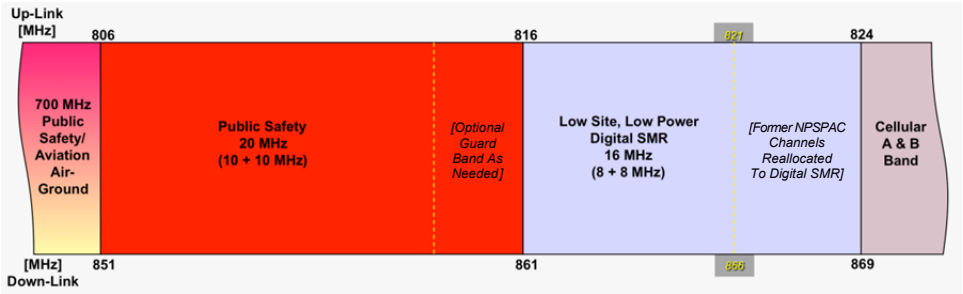
132. Over 2,200 filings claimed different positions on interference in the 800 MHz band, with "engineering, economic, legal and policy analysis" to align for a solution that would be "technically sound, effective, and equitable to the parties." 800 MHz R&O, *supra* note 125, at 15,002–10 ¶ 61. Stakeholders included APCO, Nextel, CTIA, Motorola, Public Safety Wireless Network ("PSWN"), National Association of Manufacturers ("NAM"), MRFAC (a FCC-certified frequency coordinator), B/ILT and cellular SMR licensees, 800 MHz Users Coalition (whose "balanced approach" claimed to technically solve interference to obviate need for band reconfiguration in the Consensus Plan), Anne Arundel County of Maryland (a public safety user), Verizon Wireless, Industry Canada, the city of Denver, and the city and county of San Diego. *Id.*

133. Hazlett, *Federal Preemption*, *supra* note 29, at 193 tbl.8.

134. Cellular licenses were awarded two per market, primarily by lotteries conducted by the FCC, in 1984–1989. *See* MURRAY, *supra* note 124.

135. John Shinal, *Sprint, Nextel Holders Approve Deal*, WALL ST. J. MARKETWATCH, July 13, 2005, http://articles.marketwatch.com/2005-07-13/news/30803396_1_nextel-share holders-sprint-nextel-corp-antitrust-approval; Nextel Communications, Inc., 10-K, File No. 0-19656, (Dec. 31, 2004), http://www.sec.gov/Archives/edgar/data/824169/000095013305 001019/w05804e10vk.htm; 800 MHz R&O, *supra* note 125, at 15,020 ¶ 82 ("Allocating spectrum to establish a long-term solution to the public safety interference problem and support the associated rebanding is a valid use of spectrum in the public interest.").

Figure 2: Nextel's Spectrum Reorganization Proposal: 2001[136]



De Vries and Sieh note that:

> Nextel did not pursue its claims but instead offered to provide the upfront cash to fund rearrangement of the operations in the 800 MHz band in exchange for a nation-wide license to 10MHz of contiguous frequencies in a separate band. As a result, the FCC never had to decide which parties may have been at fault.[137]

This passage describes how a profit-maximizing firm, interested in welfare-generating outcomes, pursues gains from trade. The transaction eliminates disputed borders, and dispenses with the thankless and expensive task of finding fault. Indeed, that fault determination might take forever, as the authors explain the situation as a conflict that emerged despite being a "paradigmatic example of where radio operators have both been operating within their rights."[138] In other words, the fault lay with the rules, not the parties. Yet the FCC spent years in a fruitless search for liability. By terminating that source of delay, the "spectrum swap" productively remedied harmful interference.

De Vries and Sieh, rather than heralding the mutually beneficial outcome or recommending ways to smooth the path for such solutions in the future, decry the lack of technical specificity in FCC rules: "We contend that the root cause of the [conflict] was that there had not been a sufficiently clear delineation of *who* had *what* rights according to their individual license, and what actions each party could be required to take to resolve the conflict."[139]

This view ignores (a) the costs of the FCC striving to create "sufficiently clear delineation," and (b) alternative ownership mechanisms that efficiently

136. *SMR and Cellular Frequencies Presentation*, *supra* note 130; *Nextel Interference Plan*, *supra* note 131 (graphic altered for readability).

137. DE VRIES & SIEH, *supra* note 57, at 2.

138. *Id.*

139. *Id.* at 3.

solve the coordination problem at issue. The FCC had, indeed, imposed detailed emission rights in the SMR band. These decrees were clear enough, in the De Vries and Sieh analysis, to handle the interference problem until Nextel, gaining certain regulatory waivers, began packing far more traffic—creating far more economic value—into the band. The FCC could have, at any point, adjusted boundary conditions. It failed to do so. The problem festered, and was only resolved when the FCC authorized Nextel's suggested "spectrum swap," which mimicked a secondary market transaction.[140]

Hence, the FCC's own actions and admissions reveal that the task of further rights delineation was onerous compared to the alternative of simply rearranging ownership rights using existing boundary delineations. This is not to say that there was never a problem in the conflicts between Nextel and public safety users. Quite the reverse. The actual "root" cause of the issue lay in the manner in which economic rights were defined and enforced, separate and apart from the technical specifications of border spillovers. First, the FCC allocation plan had inefficiently interspersed the use rights of rival and disparate parties, interleaving hundreds of licenses per market.[141] Second, it had then distributed licenses to thousands of parties across the nation. Third, the licensees were largely nonprofit organizations. The effect of these regulatory choices was to create a tragedy of the anti-commons, a situation where highly complementary rights are held by widely dispersed entities, making efficient rights-aggregations a high transaction cost proposition.[142]

---

140. *SMR and Cellular Frequencies Presentation*, *supra* note 130; *Nextel Interference Plan*, *supra* note 131.

141. *SMR and Cellular Frequencies Presentation*, *supra* note 130, at slide 6.

142. This point on positive transaction costs from inefficiently fragmented complementary rights by which to measure price and conduct exchange is not to be confused with strategic behavior of owners of inefficient property rights "[b]ut if the reader insists on confusing the two, so be it, but, then, please remember that situations in which strategic behavior is important are but a part, and a small part at that, of all situations that involve positive transaction cost." DEMSETZ, *supra* note 120, at 117. Demsetz also discusses the two categories of ownership problems, "the content of a privately owned bundle of rights and those that relate to the identity of the owner of the bundle." *Id.* at 95. As does Heller:

> The Russian storefront experience taught me a fundamental lesson about ownership: the *content* of property rights can matter as much as the *clarity* of ownership . . . . Regulators inadvertently fragment ownership into so many uncoordinated rights that it becomes impossible to reassemble the ownership egg, even for the state . . . . Don't forget that governments are creating property rights every day, right here, all along the innovation frontier. Corporate law, mergers and acquisitions, subprime mortgage regulations, bankruptcy law, Internet regulation—they can each create invisible tragedies of the anticommons.

Here the situation was exacerbated by the involvement of government agencies, notably difficult to remunerate for cooperating in economic bargains due to the non-economic incentives of enterprise decision-makers.[143]

The Nextel spectrum swap took too long to implement and should not have been necessary. But if the solution lay in the FCC identifying, specifying, and then implementing precise spectrum use provisions along the pre-swap boundaries, it is likely that the regulatory problem would remain unresolved and, in any event, far less value would be provided to wireless users. Instead, the problems and implemented solutions should be grasped, resulting in better regulatory policy in the future. FCC spectrum allocations should studiously avoid creating anti-commons in wireless markets through the practice of interleaving. At a minimum, licenses should be distributed by auction—including rules conducive to efficient aggregation, namely combinatorial bidding[144]—that permit markets to assemble heterogeneous assets into productive bundles. Distributing licenses to independently operated nonprofit or government organizations imposes a huge cost on future wireless solutions. Where possible, the wireless services necessary for the operations of these organizations should be purchased in the competitive marketplace, not manufactured in compartmentalized, local, government-run networks.[145] Public safety radios are bought from Motorola or Raytheon; public safety network services should also be purchased from Verizon, AT&T, Sprint, T-Mobile, Clearwire, or Globalstar (or some combination

HELLER, *supra* note 16, at 147–48 (emphasis in original). He continues: "[Russian] socialist law was more concerned with the identity of the owner than with the type of property or scope of rights. Property owned by the state received more protection than cooperative property . . . . Personal property held by individuals received the least regard of all." *Id.* at 149.

143. Cramton et al., *supra* note 122, at 664–65. Specifically note the problem created when non-profit licensees are involved in spectrum reallocations. The problem, when PCS licensees sought to buy out incumbent microwave users, extended to rate-of-return regulated utilities. The problem mirrors that of non-profit organizations in that the utility, when making an ostensibly "win win" deal to switch spectrum use, is duty-bound to relinquish any payments to ratepayers (in the form of rate reductions) so as to keep the firm's rate-of-return constant.

144. David Porter, Stephen Rassenti, Anil Roopnarine & Vernon Smith, *Combinatorial Auction Design*, 100 PROC. NAT'L ACAD. SCI. 11,153 (2003).

145. This point was discovered and argued by University of Chicago Law School student Leo Herzel in 1951. Having made the point in a comment in the law review, he was subject to mocking counter-attack from Dallas Smythe, who at one point served as FCC chief economist: "Surely it is not seriously intended that noncommercial radio users (such as the police) . . . should compete with dollar bids against the broadcast users for channel allocations." Leo Herzel, *Facing Facts About the Broadcast Business: Rejoinder*, 20 U. CHI. L. REV. 106, 106 (1952) (citing Dallas Smythe, FCC Economist).

thereof).[146] Moving license awards from "beauty contests" granting rights to non-profits reluctant to abandon them towards economically motivated for-profits enterprises will do far more to solve interference.[147]

That Nextel had to enlist the FCC to implement its trade, involving thousands of non-profit government enterprises, caused a years-long delay when compared to corresponding processes conducted with for-profit enterprises. But the solution arrived at is crucial to understand: moving use rights among organizations, not improvements in technical rules or receiver regulations, corrected the problem such that spectrum ultimately was put to supplying higher valued uses.

The delineation of interference rules has little to do with this outcome. Suppose that the FCC had, in the Nextel/public safety dispute, imposed regulations that, with full specificity and zero ambiguity, prohibited any harmful interference.[148] Suppose, further, that this rule would determine that Nextel's mobile phone network and the public safety radio services were

146. Even before accounting for very large in-kind spectrum subsidies, publicly run networks are so expensive to operate that many public safety agencies contract with private vendors (using commercial spectrum) for service. *See* Jerry Brito, *Sending Out an S.O.S.: Public Safety Communications Interoperability as a Collective Action Problem*, 59 FED. COMM. L.J. 457, 475 (2007).

147. *See* Hazlett, Muñoz & Avanzini, *supra* note 6, at 105–06 (comparing subjective "beauty contest" awards of spectrum licenses before spectrum auctions; *see also* Hazlett, *supra* note 34.

148. The FCC explicitly avoided the predictive exercise in its 800 MHz R&O:

> We also conclude we should adopt an interference protection standard in the 800 MHz band based on measured, rather than predicted signal strength. While one approach would be to define the coverage area of public safety system by a predicted signal contour, signal level prediction is an inexact science and 800 MHz radio signal propagation can be affected by multiple factors such as buildings and other obstructions, reflection of signals from nearby man-made surfaces, terrain, and foliage. Moreover, system designers frequently predict signal strengths in terms of statistical probability, e.g., the charts and algorithms used for coverage determinations predict the distance from a transmitter at which a given level of signal will be equaled or exceeded at fifty percent of the locations, fifty percent of the time. [*See, e.g.*, 47 C.F.R. § 73.699, Figures 9, 10 and 10b)]. Thus, while signal strength predictions are useful for obtaining an overall picture of system coverage, we believe they are of limited utility in predicting the strength of an 800 MHz public safety signal in a localized and relatively small area, which is exactly the type of area in which interference may be encountered from an ESMR or cellular system. Consequently, we conclude that we need to use a basis other than distance separations or predicted signal contours in establishing the threshold determination of entitlement to interference protection.

800 MHz R&O, *supra* note 128, at 15,025 ¶ 95.

incompatible: both could not continue to operate under the FCC's interleaved channel plan without spewing harmful interference.[149] Suppose, too, that the net social value of Nextel's wireless services equaled $100 billion, an estimate almost surely on the low side.[150] Suppose, finally, that the net social value of the public safety radio services supplied using the original (1982) FCC band plan was $10 billion.

Four implications of this hypothetical question are important. First, the dispute would very likely have stretched on for many more years. There is no technical solution to the question of liability, and given the dispositive importance of this determination, the FCC would be choosing between two rival economic outcomes. We surmise that public safety would be the likely winner, given its incumbency and the importance of "headline risk" to rational, utility-maximizing bureaucrats. Regardless, a considerable swath of SMR spectrum would be rendered unusable under a zero-tolerance harmful interference standard and the interleaved channel allocation.[151]

Second, under the FCC's initial band allocation, at least $10 billion, the lesser of the social contributions made by the rival SMR band services, would be lost. The simultaneous accommodation of both Nextel and public safety users was achieved not by better SMR borders but by reorganizing claims in frequency space. Imposing improved border definitions, in this situation, is

149. 800 MHz R&O, *supra* note 125, at 15,001 ¶ 101 ("In this connection, we note that almost all participants in this proceeding agree that the *status quo*—addressing interference to public safety systems on an *ad hoc* basis and reactive fashion—is no longer workable in the 800 MHz band.") (emphasis in original).

150. The 2005 price paid for Nextel was $35 billion, yielding an estimate of the present value of producers' surplus. The ratio of consumers' to producers' surplus is commonly set at ten or above. *See, e.g.*, Hazlett, Muñoz & Avanzini, *supra* note 6, at 119–20; *Welfare Analysis*, *supra* note 68, at 425 (citing J.A. Hausman, *Valuing the Effect of Regulation on New Services in Telecommunications*, Brookings Papers on Econ. Activity, Microeconomics, Vol. 1997 (1997) (for annual consumer surplus in cellular telephone licenses exceeding annual producer surplus by ten times); Rosston, *supra* note 52 (estimating "an order of magnitude more weight to consumer surplus than to the private license values").

151. The FCC avoided proposed "zero tolerance" policies as well:

> Given this fact, we believe that it would be inappropriate, as a matter of responsible spectrum management, to afford public safety systems the noise-limited coverage that some proponents have recommended. For example, were we to do so for a given public safety system in the 800 MHz band, it would not only restrict the availability of public safety spectrum in adjoining areas but also would make it virtually impossible for CMRS systems to use channels that contributed the slightest amount of noise to a public safety receiver in the far fringes of its noise-limited coverage area. Such an outcome would result in inefficient utilization of CMRS spectrum.

800 MHz R&O, *supra* note 125, at 15,024–25 ¶ 94 (citations omitted).

all about excluding the party determined to be at fault for spillovers. The clarity of rights, offered in the standard property rights context as beneficial in yielding efficiencies by internalizing effects, does not here bring with it improved modes of organization. That is because the ownership rights in public safety radio remain mired in a regulatory commons.[152] Transactions to simply exchange channels, turning an interleaved band into contiguous blocks of spectrum, are blocked on three levels: determinations of the "public interest," incentive misalignment, and the mismatch between public and private gains.

Formally, license transfers must be approved by regulators as being in the "public interest." In fact, FCC regulators generally approve license trades that have been negotiated between the parties. But such negotiations in public safety allocations are stymied by (a) the nonprofit status of the organizations, making it difficult to reward decision-makers for discovering and executing efficient deals; and (b) the extreme fragmentation of SMR licensees, numbering over 10,000 nationwide.[153] The transaction costs thus thwart the aggregation of public safety radio licenses into efficient blocks.

Third, the regulator does not internalize the social gains from choosing the correct—i.e., low cost—party to find at fault. The difference between a $100 billion and a $10 billion loss is large, but FCC officials do not pay it. They are more affected by the responses from interests that, charged with protecting life and limb in partnership with local governments, may become severely unpleasant when their slices of spectrum are threatened. An FCC decision maker is aware that $100 billion of other peoples' money may be used in two ways: not only to purchase interference protection for certain worthy radio users, but also to ensure that said official will never have to explain to a Congressional committee why America's police, sheriff, and fire departments are more important than the text-messaging addictions of middle school students.

Fourth, given the biases of regulators—who asymmetrically fear Type I errors (visible interference) far more than Type II errors (invisible interference: the services silenced to protect others)[154]—the likelihood that

152. The idea is presaged in many treatments, including the externality problem endemic in government regulation. *See* WOLF, *supra* note 78. The most direct statement may be found in HELLER, *supra* note 16, at 26: "If the regulatory drama involves too many uncoordinated actors . . . the sheer multiplicity of players may block use of the underlying resource."

153. *See generally* Brito, *supra* note 146.

154. This owes to the incentives of regulators, as briefly described in the paragraph above. The paradigm is widespread in regulatory decision-making. *See, e.g.*, Daniel Carpenter, *The Political Economy of FDA Drug Review: Processing, Politics, and Lessons for Policy*, HEALTH

these regulators can foresee which is the $100 billion opportunity and which is the $10 billion service is very low. The purpose of granting spectrum use rights to firms or individuals is to enlist the energy, dynamism, and information of competitive market forces. Because entrepreneurs are rewarded for correctly valuing assets (which is to say, buying under-priced rights and selling over-priced rights), they reveal values. Government allocations supersede this process and preempt data only the market can uncover. The administrative assignment of use rights thus embeds basic inefficiencies due to its reliance on non-market estimates of value,[155] the essence of the critique made by Ronald Coase in 1959.[156] More recent research has confirmed this perspective, mocking traditional FCC spectrum allocation as "command and control"[157] or "Gosplan."[158]

Because many of the spectrum rights at issue were not held by profit-seeking enterprises able to contract in the marketplace, the establishment of clearer borderlines between Nextel and public safety radio users was predictably an inefficient solution. It would have simply frozen usage by one of the two conflicting sets of wireless services, and outlawed the other, given

AFFAIRS, Jan.–Feb. 2004, at 52, 55–57, http://content.healthaffairs.org/cgi/reprint/23/1/52.

155. Should someone seriously believe that FCC economists can be called on to deliver timely estimates of alternative spectrum values—on a par with the values revealed by actual market transactions—the best that can be said is that they do not understand the enormity of this task. For simplification, we here consider two specific systems in conflict and give an assumed value to each. In reality, there are limitless possibilities; Nextel and the public safety radio users could combine, disaggregate, or cooperate in myriad ways, some with a little more space for Nextel, some with a little less. Mixing and matching other spectrum resources, while trading interleaved channels (the "spectrum swap" forwarded by Nextel and eventually executed by the FCC) is one example of how this could be done. That the FCC was led (here and in innumerable other instances) to act on the solution brought to it by private parties is one further bit of evidence that the valuation trade-offs are best left to parties that internalize impacts. *See generally Feds OK Nextel Spectrum Swap*, WIRED (July 8, 2004), http://www.wired.com/techbiz/media/news/2004/07/64142. For more on the "informational responsibilit[ies]" of market participants and central planners, consider Smith, *On the Economy of Concepts in Property*, *supra* note 60, at 2114.

156. Coase's analysis leaned heavily on Adam Smith's view of the importance of decentralized decision making. It also incorporated Friedrich A. Hayek's view that such decentralization was efficient when decision makers were incentivized to productively use specific information of "time and place." Asset owners pursuing value maximization are subject to such incentives. *See* R. H. Coase, *The Federal Communications Commission*, 2 J.L. & ECON. 1, 18 (1959); *see generally* Friedrich A. Hayek, *The Use of Knowledge in Society*, 35 AM. ECON. REV. 519 (1945).

157. NBP 2010, *supra* note 3, at 79.

158. Gerald R. Faulhaber & David J. Farber, *Spectrum Management: Property Rights, Markets and the Commons* 6 (AEI-Brookings Joint Center for Regulatory Studies, Working Paper 02-12, Dec. 2002), http://www.ictregulationtoolkit.org/en/Document.3629.pdf.

the impossibility (prohibitive transaction costs) of recontracting. This is what results when the goal of the regulatory task is limited to finding fault—"Gosplan."[159]

A superior result was, in fact, obtained. The FCC executed a spectrum swap that left technical rules in place but rearranged the economic structure of spectrum rights.[160] The implication for public policy is that such transactions—routine in the market when exclusive, liberal rights control the relevant spectrum—demonstrably improve upon the performance of administrative allocation. To focus on more sophisticated rights definitions, as suggested by Matheson & Morris (2011) or De Vries & Sieh (2011), ignores the available lessons.[161] Efforts to fine tune border definitions were, at best, costly diversions.[162] The solution came in undoing the problems of interleaving, fragmentation, non-profit rights ownership, and spectrum integration by merger.[163] That FCC fiat was required to impose this mutually

159. *Faulhaber*, *supra* note 158.

160. The FCC rejected over specification and relied on economic reconfiguration:

> Thus, although we have discussed herein the technical means disclosed in the record to avoid unacceptable interference—especially those that come within the definition of Enhanced Best Practices—we reject as unnecessary, the recommendations of some parties for mandatory restrictions on all ESMR and cellular systems with respect to such parameters as maximum cell ERP, combiner technology, and specific antenna pattern characteristics.

800 MHz R&O, *supra* note 125, at 15,028 ¶ 103 (footnotes omitted).

161. *See infra* note 163.

162. The FCC declined receiver standards, and interference temperatures, proposed to technically solve border interference:

> The Consensus Parties proposed that full interference protection would be provided only for systems using receivers that satisfy TIA Class A specifications. Receivers not conforming to these specifications would be protected only to some higher desired signal threshold power level. Several parties supported the Consensus Parties in this regard; while others disagreed, pointing out that some of the TIA standard parameters, for example, operating temperature range of the radio are irrelevant to 800 MHz interference and therefore that the Commission should not require compliance with the entire standard but, instead, should simply adopt minimum intermodulation rejection ratios for receivers.

800 MHz R&O, *supra* note 125, at 15,026–27 ¶ 99 (footnotes omitted).

163. In fairness, MATHESON & MORRIS, *supra* note 56, and DE VRIES & SIEH, *supra* note 57, at 66, both mention the importance of avoiding fragmentation in rights issuance. Goodman also touches on the complex burden on interference rules when spectrum sharing is authorized not by liberal licenses but in unlicensed allocations:

> Things take longer when no one can be held accountable for interference. One of the complications of unlicensed use, however desirable it may be, is that it's hard to assign responsibility for interference. This difficulty

beneficial solution on nonprofit licensees is an important lesson first explained by Leo Herzel in 1951.[164] And, as Demsetz has more recently explained, the transactionally efficient way to solve most externality problems is to allow the market trades to eliminate borders altogether, a proxy for what finally remedied the conflicts in the SMR band (as seen in Figure 3).[165]

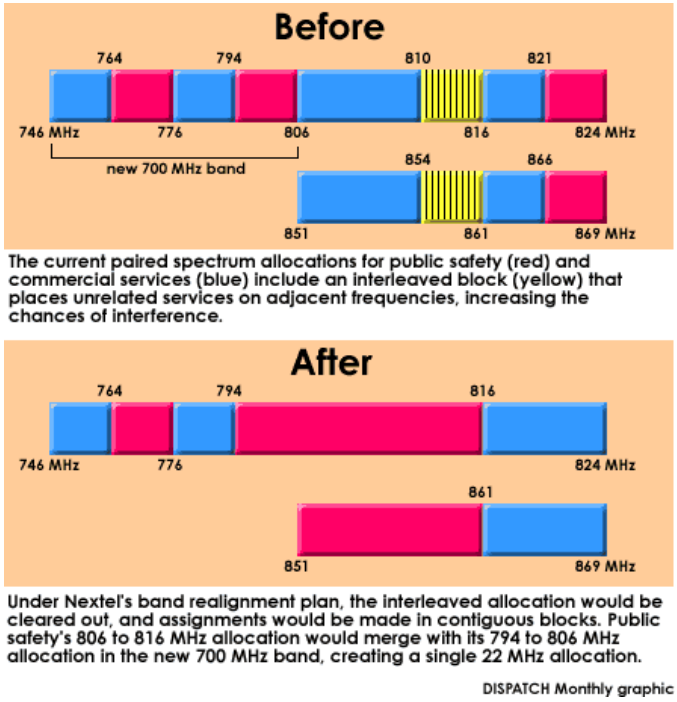
> buttresses the already existing tendency towards conservative allocations and is one of the reasons the White Spaces decision took so long.

Goodman, *supra* note 54, at 507. These are important inclusions, but they are discussed in each of the analyses as stand alone considerations. They are not. The reliance on well-crafted, economically efficient spectrum rights bundles is key to welfare maximization. The expenditure of time and scarce regulatory resources on technical specificity directly undermines this path. "Such [cellular/PCS] systems can substantially increase the ability of base stations to re-use frequencies without increasing interference, and illustrate the importance of including direction of propagation as a dimension of spectrum rights." MATHESON & MORRIS, *supra* note 56, at 14. "The direction of propagation is likely to be an increasingly important dimension across which to partition rights to access spectrum." *Id.* at 15. MIMO, dynamic sensing and spectrum reuse should allow regulators *less* involvement in detailing borders, but path-dependency of the specification exercise remains. *See* DE VRIES & SIEH, *supra* note 57, at 63–64 ("Rights not assigned are deemed to be in the public domain and can be appropriated by any operator—but only until the next license renewal point, at which time the regulator may add rights to the licenses specifying these parameters"); *see also* MATHESON & MORRIS, *supra* note 56, at 37 ("[D]ifferent technologies may be better suited to different sets of unlicensed rules, and there is no way for the FCC to ensure that its portfolio of different rules in different unlicensed bands is efficient.").

164. Herzel, *supra* note 145.

165. *See* Demsetz, *supra* note 47.

Figure 3: Nextel/Public Safety Conflict Resolution[166]



F. INTERFERENCE TEMPERATURE: A FAILED ATTEMPT AT GREATER CLARITY

In the spectrum policy literature, an idea that is prevalent (and correct) is that there is a great deal of unused or under-utilized spectrum: "[T]here is no real debate that our current system of spectrum rights keeps some lower valued uses on wireless frequencies at the expense of higher-valued uses."[167]

166. *800 MHz Interference Issue Rebanding*, DISPATCH MAGAZINE, http://www.911dispatch.com/info/800_transition/index.html (last visited Mar. 1, 2013).

167. Stuart Minor Benjamin, *Roasting the Pig to Burn Down the House: A Modest Proposal*, 7 J. TELECOMM. & HIGH-TECH L. 95, 95–96 (2009); *see also* NBP 2010, *supra* note 3, at 78–79:

> In the case of commercial spectrum, the failure to revisit historical allocations can leave spectrum handcuffed to particular use cases and outmoded services, and less valuable and less transferable to innovators who seek to use it for new services. The market for commercial, licensed spectrum does not always behave like a typical commodities market. Commercially licensed spectrum does not always move efficiently to the use valued most highly by markets and consumers. For example, a megahertz-pop may be worth a penny in one industry context and a dollar in another. Legacy "command and control" rules, high transaction costs and highly fragmented license regimes sometimes preserve outmoded band plans and prevent the aggregation (or disaggregation) of spectrum into more valuable license configurations.

But there is a distinct split as to how that process should be achieved. Economists tend to see the underutilization, as did Coase, as caused by a lack of ownership rights.[168] Without responsible economic agents to conserve or extend resource value, productive opportunities are squandered. The sharp contrast between spectrum allocated to liberal licenses—generating heavy investment in complementary network infrastructure, so it can yield value by being intensely shared—and restrictive licenses, such as those governing over-the-air television broadcasting, is emblematic of the efficiencies that might be realized if more licenses were liberalized.[169] As is, traditional licenses allocating prime spectrum typically return far less than their social opportunity cost in social welfare gains.[170]

Lawyers and engineers, on the other hand, often see the underutilization as endemic in all licensed spectrum. Even in liberally licensed bands, full utilization is rare: almost all bands could host additional wireless services during certain parts of the average day.[171] Given sophisticated radio technologies that identify vacant channels and avoid conflicts with competing radio emissions, society could benefit; however, the government would need to craft rules that allowed ad hoc access to almost any unused spectrum resources. This would, arguably, make much more bandwidth

Id.

168. Not only economists take this position, of course. *See* Benjamin, *supra* note 167.

169. Underuse and overuse, compared to ordinary use and optimal use, are concepts that "reorient[] policymaking from relatively simple either-or choices to the more contentious trade-offs that make up modern regulation of risk." HELLER, *supra* note 16, at 35–37. "Today, for many observers, the property trilogy can be reduced to an opposition of private and commons property, what one scholar calls simply, 'all or none.' I believe a substantial cause of our cultural blindness to gridlock arises from this too simple image of property." *Id.* at 34 (citing YORAM BARZEL, ECONOMIC ANALYSIS OF PROPERTY RIGHTS 71 (Cambridge University Press 1989)).

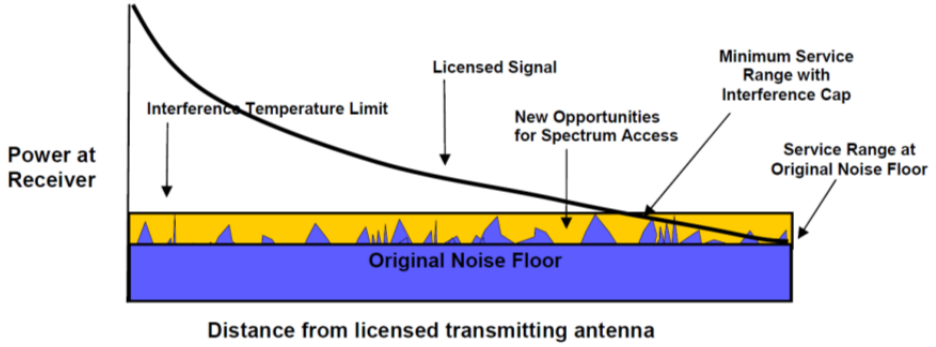
170. This is not to say that broadcast TV content is lacking in value, but that the broadcast TV distribution platform—transmissions to roof-top antennas—is obsolete. As over 90% of households receive their video content (including broadcast TV signals) via cable or satellite TV connections, and given that boosting that rate to 100% would require another $3 billion to "complete" the grid, the forty-nine TV channels (6 MHz each, or 294 MHz all told) allocated for broadcasting have extremely modest social value. *See* Hazlett, *A Proposal for an Overlay Auction*, *supra* note 50. In comparison, the consumer surplus that would be generated by allowing all TV band frequencies to be used for mobile communications services easily exceeds $1 trillion. *Id.*

171. Capacity utilization, whether considered optimal, average, stochastic, or probabilistic, is rarely at full capacity in any resource channel; consider fluctuations of electricity usage, vehicular traffic, seasonal factory orders, auto-scaling Amazon Web Services, emergency safety services, and military services. Spectrum users face the same economic capacity utilization choices. *See SPTFR*, supra note 1, at 21.

available for both existing and new, innovative wireless services, fueling economic growth.

The latter view sees the problem of white spaces as a technically defined problem that can be fixed by engineering rules that provide for optimal spectrum sharing. As seen in Figure 4 below, wireless systems using licensed spectrum (liberal or traditional regimes) tend to leave some frequency space unoccupied at least some of the time. By simply drawing rules about where new ad hoc radio transmissions can fit (in an additional noise floor, denoted in yellow in Figure 4), the theory is that extra communications capacity can be forged.

Figure 4: FCC Proposal for an "Interference Temperature"[172]



This view is deeply flawed. Were such spaces being wasted, liberal licensees would have every incentive not only to know that fact, but to invest in technologies, radios, or new network architectures to exploit the waste.[173] Of course, the gains from using the vacant spaces must profitably exceed the costs of packing more traffic into the frequency space. Because all such traffic is stochastic and powerful, exhibiting both cyclical and random

172. In the Matter of Establishment of an Interference Temperature Metric to Quantify and Manage Interference and to Expand Available Unlicensed Operation in Certain Fixed, Mobile and Satellite Frequency Bands, Notice of Inquiry and Notice of Proposed Rulemaking, 18 FCC Rcd. 25,309, 25,315 (2003) [hereinafter 2003 Interference Temperature Metric NOI & NPRM], *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-03-289A1.pdf.

173. That new technologies increase spectrum productivity from spectrum inputs only emphasizes the importance of liberalizing the spectrum to absorb technical specifications into larger bundles of complementary use rights. Consider the opposing forces between technical innovation and regulatory liberalization. *See* DE VRIES & SIEH, *supra* note 57, at 67 ("DSA aims for higher density and more transience of use than conventional static allocations . . . ."). *But see id.* ("However, there are many flavors of DSA that can be classified according to distinctions, such as: coordinated vs. uncoordinated; cooperative vs. non-cooperative; homogeneous vs. heterogeneous uses; and co-primary, primary-secondary or co-secondary legal status.").

fluctuations in demand, along with similar perturbations in propagation characteristics, networks are typically designed to feature some optimal level of slack. Indeed, quality of service ("QoS") is highly correlated with the consistency of network performance.[174] However, the probabilistic aspects of radio technology that are raised as impediments to drawing private property rights in spectrum actually cut just the opposite way.

First, lines that are hard to draw for private owners are equally hard to draw, in technical terms, for limited use rights narrowly defined and then assigned by regulators.[175] This is the basic point Coase made in his "Social Cost" paper.[176] Second, the essential trade-offs of harmful interference are both complex and economic in nature. By both logic and historical observation, spectrum regulators have no comparative advantage in determining what these trade-offs are or how best to resolve them.

This was demonstrated rather powerfully in the proceeding opened by the FCC in 2003 to establish an "interference temperature."[177] Driven by the technical view of radio interference,[178] the Commission sought to allow ad hoc access, by using unlicensed radio devices, in the low-power spaces found in the noise floor of frequency bands allocated to both liberal and traditional licenses.[179] In the bands allocated to traditional licenses, vast white spaces

174. *See* Gregory Sidak & David Teece, *Innovation Spillovers and the "Dirt Road" Fallacy: The Intellectual Bankruptcy of Banning Optional Transactions for Enhanced Delivery Over the Internet*, 6 J. COMPET. L. & ECON. 521 (2010) (discussing the economics of innovation in quality of service ("QoS")).

175. Consider the role of the regulator in renewal of limited rights:

> Rights not assigned are deemed to be in the public domain and can be appropriated by any operator—but only until the next license renewal point, at which time the regulator may add rights to the licenses specifying these parameters. For example, a transmission permission may limit resulting energy at or below an altitude of 1.5 meters, but say nothing about operation at 1,000 meters; thus a surveillance drone operator a [sic] would be able to exceed the specified 1.5 meter transmit power at 1,000 meters.

DE VRIES & SIEH, *supra* note 57, at 8–9.

176. Coase, *supra* note 44. For a detailed explanation of this point, often lost in confusion over the "Coase Theorem," see Thomas W. Hazlett, *Ronald H. Coase*, *in* PIONEERS IN LAW AND ECONOMICS, CHAPTER 1 (Lloyd R. Cohen & Joshua D. Wright, eds., Edward Elgar 2009). *See generally* Interview by Russ Roberts with Ronald Coase, *Coase on Externalities, the Firm, and the State of Economics*, Podcast on *EconTalk*, LIBRARY OF ECONOMICS AND LIBERTY (May 21, 2012), *available at* http://www.econtalk.org/archives/2012/05/coase_on_extern.html (explaining misunderstandings of the "Coase Theorem").

177. 2003 Interference Temperature Metric NOI & NPRM, *supra* note 172, at 25,312 ¶ 8.

178. *Id.* at 25,317–18 ¶ 21.

179. *Id.* at 25,315 ¶ 16.

often exist, making some new unlicensed uses relatively uncontroversial. But the spectrum licensed to liberal licenses is not only intensely used, but mobile carriers using such frequencies are also continually engaged in the process of making the noise floor quieter, so as to allow greater traffic to generate higher revenues.[180] Moreover, such networks are continually cutting deals with third parties, such as wholesale mobile operator agreements, vendor equipment (handsets, tablets, modems, etc.) joint marketing contracts, and application platforms, to use spectrum allocated liberal licenses more fully and profitably.[181]

A broad misunderstanding concerning the nature of exclusive rights merits attention here. It is commonly asserted that unlicensed spectrum access categorically entails lower (or no) licensing expense. Transactions costs in using exclusive spectrum rights are incurred due to the "hassle" inherent in the "need for a license to operate the device . . . ."[182] These costs, it is asserted, are avoided in unlicensed bands, saving resources and speeding innovative wireless services to market.[183] Charles L. Jackson provides a numerical example, estimating that "the spectrum occupied" by one remote wireless car key in one day "is worth one ten-thousandth of a cent" in terms of the bandwidth consumed.[184] The efficiency of unlicensed access is found in Jackson's further estimate that "a consumer would need spend only about one-thousandth of a second contemplating an FCC license form before the transactions costs exceeded ten times the value of the spectrum used by the device."[185]

The value estimates are plausible, but the conclusion is flawed. When exclusive spectrum rights are issued to profit-maximizing enterprises, licensees then seek to avoid needless transaction costs. Hence, when cellular carriers resell spectrum rights to mobile subscribers, subscribers need not

180. *See* Rath, *supra* note 28, at 529 ("These are not massive, one-time negotiations between companies, but involve hundreds of individual negotiations between companies' engineers who are tasked with the day-to-day operations of the network.").

181. Fifteenth Annual Competition Report, *supra* note 20, at 9698 ¶ 32, 9751–52 ¶ 138; 9757–58 ¶ 154 (2011).

182. Kenneth R. Carter, Ahmed Lahjouji & Neal McNeil, *A Joint OSP-OET White Paper on Unlicensed Devices and Their Regulatory Issues* 5 (FCC, OSP Working Paper No. 39, May, 2003), *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-234741A1.pdf.

183. *Id.* ("Because they are free from the delays inherent in the licensing process, unlicensed devices can frequently be designed to fill a unique need and be introduced into the marketplace rather quickly. The availability of spectrum for use by unlicensed devices has spawned a variety of new applications.").

184. Charles L. Jackson, *The Genesis of Unlicensed Wireless Policy*, 11 INFO 2 n.4 (Aug. 2009).

185. *Id.*

obtain licenses to use that spectrum—not once, let alone every time they dial a call, send a text, or check email. Contracts are arranged by monthly billings or prepaid cards with set prices. Indeed, marketing innovations like "digital one rate," a fixed price for a monthly "bucket of minutes," or unlimited off-peak, on-net, or texting usage remove even more of the pricing overhead.[186] The cost of billing is not zero, of course, but the opportunity to bill is a feature, not a bug. Payments from spectrum users reveal the value of service and support the creation of complementary infrastructure, including wide area wireless networks that dominate value creation (including those found in TV and unlicensed bands).[187]

All costs, including the direct costs of customer billing for use, shrink when economic incentives are properly aligned. Exclusive ownership rights tend to do that. Whatever approaches the FCC may employ to reduce licensing costs, after licensing exclusive spectrum rights with liberal use rules, can be employed by private parties. The unlicensed approach, allowing customers to buy approved FCC devices and then "plug-and-play" without further transactions, is commonly adopted in the use of licensed spectrum.[188] Phones purchased at 7-Eleven or Walmart sold by mobile virtual network operators ("MVNO") such as TracFone, need no carrier contract.[189] Nor does Amazon Kindle, where book or movie downloads are delivered seamlessly over a carrier's mobile network, unseen by the user, who bargains with Amazon.[190] It is undeniably true that the initial licensing round is costly, but the regulatory process largely imposes that cost. Moreover, parallel processes are implicated in the initial allocation of spectrum for unlicensed use. The FCC proceeding to permit unlicensed access to TV Band white

186. Fifteenth Annual Competition Report, *supra* note 20, at 9724 ¶ 81 ("bucket" of minutes); In the Matter of Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993 Annual Report & Analysis of Competitive Mkt. Conditions with Respect to Mobile Wireless, Including Commercial Mobile Servs., Eleventh Report, 21 FCC Rcd. 10,947, 10,983–94 ¶ 90 (2006) [hereinafter Eleventh Annual Competition Report], *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-06-142A1.pdf (AT&T Wireless's introduction of the "digital one rate" in 1998).

187. Hazlett & Leo, *supra* note 97.

188. Eleventh Annual Competition Report, *supra* note 186, at 10,961 ¶ 30.

189. Fifteenth Annual Competition Report, *supra* note 20, at 9731 ¶ 98; Search Result for "TracFone," WALMART, http://www.walmart.com/search/search-ng.do?search_query=tracfone (last visited Nov. 26, 2012) (offering prepaid TracFone phones); No-Contract Phones, 7-ELEVEN, http://www.7-eleven.com/Play/No-Contract-Phones/Default.aspx (last visited Nov. 26, 2012) (offering a TracFone Samsung T245G).

190. Press Release, Amazon.com, Inc., Amazon Takes on the High-End—Introducing the New Kindle Fire HD Family (Sept. 6, 2012), http://phx.corporate-ir.net/phoenix.zhtml?c=176060&p=irol-newsArticle&ID=1732546 (stating that Amazon named AT&T as a contracted provider of LTE data service).

spaces has dragged on for ten years, yet there are still no commercial deployments.[191] Difficult choices are made about rules to control harmful interference, choices made by regulators having no stake in the matter and subject to no cost in delays.[192] In point of fact, licensing is not avoided in unlicensed allocations—it is the device that is licensed, not the operator. These approvals, as seen, may take many years.

It is even more costly when a spectrum is frozen in sub-optimal use because the unlicensed adopted (or contemplated) use does not allow efficient spectrum reallocation to take place in the marketplace. This is precisely the situation in the TV Band. Thanks to both the traditional TV licensing scheme, which reserves all but a very few narrow, well-specified, seemed-like-a-good-idea-in-1952-broadcasting spectrum rights in the hands of regulators, and the decade-long, policy focus on sprinkling unlicensed access rights in the voluminous white spaces (a product of the rigid and obsolete government spectrum use rules), the U.S. economy loses perhaps $100 billion or more in annual social welfare.[193]

---

191. In the Matter of Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band, Notice of Inquiry, 17 FCC Rcd. 25,632 (2002); In the Matter of Unlicensed Operation in the TV Broadcast Bands & Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band, Notice of Proposed Rulemaking, 19 FCC Rcd. 10,018 (2004); In the Matter of Unlicensed Operation in the TV Broadcast Bands & Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band, Second Memorandum Opinion and Order, 25 FCC Rcd. 18,661 (2010) [hereinafter 2010 White Spaces Second Memorandum R&O]. "[A]ll TV bands devices to be certified by the FCC Laboratory. The Laboratory will request samples of the devices for testing to ensure that they meet all the applicable requirements." 2010 White Spaces Second Memorandum R&O, *supra*, at 18,667 ¶ 11. Since the *2008 SR&O*, the latest progress includes orders to certify database administrators, and a report of basic protocol specifications. Two white space devices have been tested by the FCC Laboratory as of 2011, after IEEE released 802.22 in July 2011. *See* In the Matter of Unlicensed Operation in the TV Broad. Bands & Additional Spectrum for Unlicensed Devices Below 900 Mhz & in the 3 Ghz Band, Order, 26 FCC Rcd. 554 (2011); In the Matter of Unlicensed Operation in the TV Broad. Bands & Additional Spectrum for Unlicensed Devices Below 900 Mhz & in the 3 Ghz Band, Order, 26 FCC Rcd. 10,599 (2011); Report of the White Space Database Administrator Group, DA 11-131 (Sept. 12, 2011); *Database-to-Database Synchronization Interoperability Specification*, Version 1.01; IEEE-Standards Association, IEEE 802.22™*-2011 Standard for Wireless Regional Area Networks in TV Whitespaces Completed.*

192. Goodman, *supra* note 54, at 506 (noting the added difficulty inherent in the unlicensed rules, specifically tying this to the TV band "white spaces" regulatory delay); *see also* DE VRIES & SIEH, *supra* note 57, at 56 ("The operating parameters for unlicensed devices would be revisited at regular intervals, say ten years, just as licensed parameter sets are reviewed at license renewal."). Historically, the time of review through the FCC administrative process has taken six to thirteen years. *NBP 2010*, *supra* note 3, at 79.

193. Hazlett, *A Proposal for an Overlay Auction*, *supra* note 50, at 3 n.2. This is a back of the envelope calculation, leveraged on the proposition that if just 200 MHz of actively used

Indeed, the real transaction cost issue is the reverse of what Jackson has offered. While private rights to control spectrum can and should produce resource owners highly motivated to reduce transaction costs, a regulatory system that ambitiously attempts to preempt the market's approach must largely engage in the "command and control" system of spectrum allocation that yields such poor results today. That is, when regulators are to decide where unlicensed access is more efficient, they must then evaluate all band rules individually. Unlicensed allocations, further, are not unregulated. They require policing, as Charles Jackson, Raymond Pickholz and Dale Hatfield have explained.[194] Such bands, to avoid the tragedy of the commons, come equipped with coordinating rules: power limits, technology restrictions, and (sometimes) business model regulations. These rules are imposed by regulators, and can only be changed by regulators. The bottom line is that liberal licensed and unlicensed allocations are two rival means of dealing with harmful interference. Neither path is free. It is appropriate to compare the total costs and benefits of either approach in selecting a framework for choosing among them.

The FCC's attempt to establish an interference temperature underscores how elusive and expensive the unlicensed approach could be. The Commission argued that its effort to establish clear metrics would give "greater certainty" through "specifying a potentially more accurate measure of interference" to licensees regarding interference their services might suffer from the noise floor.[195] But this path to great clarity was worth much less than it cost—or so liberal licensees believed, as witnessed by their strong opposition to the proceeding. They already exercised de facto control of the spectrum resources in question. Borders were not explicit, but were good enough for large networks to be created and operated. As explained in detail elsewhere,[196] the government did not solve any market failure with its purported imposition of a technically defined border for the noise floor, but threatened to impose a tragedy of the commons on highly productive resource owners by introducing fragmented spectrum use rights that could not be reconfigured due to open access. Despite the FCC's aims to pave the way for dynamic access to licensed spectrum with rules protecting owners

CMRS spectrum in 2008 generated at least $200 billion in voice service consumer surplus, another 294 MHz of (even better VHF-UHF) spectrum might be worth, at the margin, at least half again as much. The guesstimate here is to establish order of magnitude.

194. *See* Charles Jackson, Raymond Pickholtz & Dale Hatfield, *Spread Spectrum Is Good—But it Does Not Obsolete* NBC. v. U.S.*!*, 58 FED. COMM. L.J. 245 (2006).

195. *2003 Interference Temperature Metric NOI/NPRM*, *supra* note 172, at 25,309 ¶ 1.

196. *See, e.g.*, Thomas W. Hazlett & Matthew L. Spitzer, *Advanced Wireless Technologies and Public Policy*, 79 S. CAL. L. REV. 595 (2006) [hereinafter *Advanced Wireless Technologies*].

against harmful interference, as measured by spectral analyzers evaluating radio emissions, the Commission conceded failure. In 2007 it abandoned the effort, stating:

> Commenting parties generally argued that the interference temperature approach is not a workable concept and would result in increased interference in the frequency bands where it would be used. While there was some support in the record for adopting an interference temperature approach, no parties provided information on specific technical rules that we could adopt to implement it.[197]

It should not go unnoticed that the enthusiasm for FCC-driven solutions to spectrum sharing is so great that commentators today lament this outcome, arguing that the Interference Temperature proceeding and Receiver Standards proceeding should be brought back to life, despite the fact that the regulators needed to define such metrics have closed the matter.[198]

IV. BEYOND EXACTITUDE: ENABLING OPTIMAL COMBINATIONS

A. BASIC STRATEGY

> There are various combinations of resources—transmission power, antenna height and directivity, frequency of transmission, method of propagation, etc.—that can be utilized to achieve a given level of (received) power at a point distant from the point of transmission. The *range* of alternative combinations is determined by technology—the state of the arts—and is an engineering problem. The "proper" combination actually to use to achieve a given goal is, however, an *economic* problem and is not (properly[)] soluble solely in terms of engineering data.[199]

---

197. In the Matter of Establishment of an Interference Temperature Metric to Quantify & Manage Interference & to Expand Available Unlicensed Operation in Certain Fixed, Mobile & Satellite Frequency Bands, Order, 22 FCC Rcd. 8938 (2007) (internal citations omitted).

198. DE VRIES & SIEH, *supra* note 57, at 62 ("However, it would likely not take such a step since limiting the number of receivers . . . is politically unrealistic, and attempting to specify receiver standards . . . has proven difficult in the US as a general matter") (citing In the Matter of Interference Immunity Performance Specifications for Radio Receivers, Notice of Inquiry, 18 FCC Rcd. 6039 (2003)).

199. COASE, MECKLING & MINASIAN, *supra* note 37, at 23. For an explanation of why Coase's RAND paper was suppressed for over three decades, see Ronald H. Coase, *Comment on Thomas W. Hazlett, Assigning Property Rights to Radio Spectrum Users: Why Did FCC License Auctions Take 67 Years?*, 41 J.L. & ECON. 577, 579 (1998) (responding to Hazlett, *Why Did FCC License Auctions Take 67 Years?*, *supra* note 34).

This profound summary of the coordination problem in spectrum allocation was offered by three economists a half-century ago.[200] Their analysis was rendered a priori, based almost wholly on economic theory and before they could directly observe the empirical result of their proffered system for allocating radio spectrum rights via market mechanisms. They had observed the rigidities and presumed inefficiencies of the administration allocation model, however, where airwave transmissions were narrowly constrained by law. The performance of this system led them to conclude that an alternative regime vesting decentralized licensees with the flexibility to change spectrum uses according to profit-and-loss criteria would improve social coordination, producing substantially greater economic output.

This approach has been strongly supported by the data generated over the intervening decades when, in fact, liberal spectrum rights were defined and distributed by regulators in the United States and elsewhere. In mobile markets licensees have been generally afforded wide latitude to control pricing, services, business models, the deployment of wireless technologies, the location of base stations, and the mobile devices used by subscribers. Private market transactions determine, for example, how a mobile phone communicates with the base station, what power it uses, what technical format is deployed (GSM, CDMA, LTE), and how the customer pays for her subscription. These are all dimensions that were (and in many cases still are) determined by the FCC in traditional wireless licenses.[201] The outcome of this liberalization in mobile services has been an eruption in productive activity, with a complex ecosystem emerging in which technology suppliers, app developers, equipment manufacturers, investors, wireless carriers, and consumers coordinate the use of myriad inputs, including radio spectrum, in a competitive quest to achieve the " 'proper' combination."[202]

How is it known that the market outcome in mobile is superior per the liberal spectrum rights issued to enable it? It is not a trivial question. Perhaps administrative allocation would do as well to accommodate the emerging marketplace. The evidence against this view is persuasive, however. First, the regulators themselves have come to this conclusion, which might be characterized as an admission against interest. In the United States, the FCC

200. *See* COASE, MECKLING & MINASIAN, *supra* note 37.

201. For an overview of commercial broadcast licenses, see In the Matter of Annual Assessment of the Status of Competition in the Market for the Delivery of Video Programming, Fourteenth Report, 27 FCC Rcd. 8610, 8646 ¶¶ 176–177 (2012) [hereinafter Fourteenth Video Competition Report], *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-12-81A1.pdf (describing regulatory conditions on the entry and exit of broadcast television stations, license transfers, and media ownership limits).

202. COASE, MECKLING & MINASIAN, *supra* note 37, at 23.

has argued that the mobile market has developed with a great number of efficiencies due to the nature of the spectrum rights issued.[203] Second, virtually all governments have moved decisively away from the traditional licensing model in mobile services. While some countries have retained technology restrictions (e.g., mandating GSM in 2G licenses in the European Union, while prohibiting broadband), the discretion afforded licensees is far beyond what is delegated in the operating permits issued prior to the advent of mobile services.[204]

Third, for decades the mobile phone market was governed by traditional licenses, and it sputtered. This was because the "land mobile" licenses, narrowly crafted, did not permit cellularization. The 64-kb/s coding rate for twenty-four voice circuits on a standard T-1 wire used in a major city, such as St. Louis, would accommodate just twenty-four phone calls at one time.[205] While cellular technology was developed at Bell Labs in 1947, it took until 1989 for U.S. regulators to authorize the technology.[206] However one calibrates the delay, it was profound, and forms an oft-used reference point in gauging regulatory lag in spectrum allocation.[207] Even during the latter years of this process, when cellular systems were actively considered by policy makers, regulators proceeded cautiously, at least in part, because they believed that the service in question would never be of interest to mass market consumers. They saw it, wrongly, as a niche status symbol, of interest only to luxury car buyers and salesmen.[208] Market planning under standard allocation rules, in short, exhibited non-market failure.

Fourth, those countries that have gone most decidedly towards deregulation in mobile spectrum allocations by attempting to issue de facto spectrum licenses have emerged with relatively competitive, well-developed

---

203. *Wireless Bureau Chief Daniel Phythyon Hails Success of Market-Based Spectrum Policies*, *supra* note 20.

204. Fifteenth Annual Competition Report, *supra* note 20, at 9734 ¶ 106 n.303 (describing the European mandate on a single harmonized standard in GSM in 2G services in the early 2000s).

205. *See* GEORGE CALHOUN, DIGITAL CELLULAR RADIO 178, 194 (Artech House 1988). The digital coding rate is near 4.8 kb/s today. *Id.* at 194. Some voice codecs use 5.3 kb/s. *See* Bur Goode, Voice Over Internet Protocol (VOIP), 90 Proceedings of the IEEE 1495, 1497 (2002), *available at* http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=1041060.

206. For a history of the cellular allocation, see CALHOUN, *supra* note 205. For a discussion of the license assignment process in cellular, see Thomas W. Hazlett & Robert J. Michaels, *The Cost of Rent Seeking: Evidence from the Cellular Telephone License Lotteries*, 59 SO. ECON. J. 425 (1993).

207. NBP 2010, *supra* note 3, at 79, Exhibit 5-C.

208. *See* MURRAY, *supra* note 124, at 50, 277.

mobile markets.[209] This suggests that there are no significant advantages associated with whatever remains of top-down regulatory rules.

Finally, both the aggregate levels of liberally licensed spectrum and marginal increments have been found to generate extremely high social value. The spectrum used in the United States for mobile services in 2008, about 200 MHz, produced annual consumer surplus in excess of $200 billion.[210] And additional bandwidth, allocated via mobile licenses, would produce substantial new value. A 30 MHz increment in the United States from 1997 to 2003 (during which the "PCS C-block fiasco" blocked the use of a similar amount) would have generated an extra annual consumer surplus of approximately $10 billion (in constant 2000 dollars).[211] That these bandwidth additions support new and highly valuable services implies that it is the liberal license regime that best supports investment.

Liberal usage rights are effective social tools for discovering the optimal mixes for spectrum. Not just of basic structures or business models, but in foraging through the countless tradeoffs: when to route traffic through fixed, wired networks versus mobile wireless; when to upgrade technologies versus adding queuing times or splitting more cells; when to allocate more bandwidth to data services; reducing the quality of some voice calls during high-use peak times but increasing the speed of online access; and how much to subsidize new handsets, which is expensive for the network but helpful both in improving users' experience and in reducing network congestion, since the newer technologies generally use lower power levels and have better processing techniques.

It is often argued that the spectrum allocation system should provide for a mix of services and business models and market structures.[212] Of course. But the implication drawn is that the government needs to impose this mix, and thereby determine the relative size (and rules) of the alternative

209. Four such countries (New Zealand, Australia, Guatemala and El Salvador) are discussed in Hazlett, *Wireless License Values*, *supra* note 72. *See also* Thomas W. Hazlett, Giancarlo Ibarguen & Wayne A. Leighton, *Property Rights to Radio Spectrum in Guatemala and El Salvador: An Experiment in Liberalization*, 3 REV. L. & ECON. 437 (2007).

210. Hazlett, Muñoz & Avanzini, *supra* note 6, at 100 tbl.1 (noting $211.8 billion in 2009 in 2008 dollars).

211. *Welfare Analysis*, *supra* note 68, at 436 tbl.5.

212. Ellen P. Goodman, *Spectrum Rights in the Telecosm to Come*, 41 SAN DIEGO L. REV. 269, 384 (2004) (noting a mixed regime of uses in the spectrum telecosm, with diversity in possible usage patterns, ranging from conservation, individual ownership, community ownership, widely-shared use, narrowly-shared use, limited access, and privately licensed bands).

allocations. That is clearly the systemic source of the problems, which, by consensus, plague the spectrum allocation process.[213]

The relevant public policy question is precisely how the optimal mix of models should be determined. Administrative allocation rests choices with dispassionate agents who prosper according to how well they play a political, bureaucratic game, a contest that rewards incumbent protection or stasis more frequently than it welcomes entrepreneurial innovation. Coase argued that responsible economic agents with strong incentives to internalize costs and benefits are theoretically attractive actors for this task. By revealing how actual markets operate (with real-world rigidities, transaction costs, and regulatory constraints), market evidence now tends to confirm Coase's hypothesis. Current policy analysis also fails to appreciate that "spectrum commons" allocations (a euphemism given to unlicensed bands that are effectively controlled not by a group of owners, as in a commons, but by state regulators) do not uniquely rely on the case-by-case allocation system in place in the United States since 1927. A market-oriented policy that generally liberalized exclusive spectrum usage rights and distributed them to the market would have ample scope for bandwidth regulated in the way that unlicensed bands are overseen today. The government (or other for-profit or non-profit agency) would acquire exclusive rights in market transactions; the state has the added advantage of potentially using condemnations or gifts to reorganize spectrum. The government acquires land for public parks in this manner. Indeed, public parks are given as explicit analogies to unlicensed bands, but such "commons" are constrained in form and function by land markets relying on private ownership rights.[214] These markets afford price information that greatly rationalizes purchases or sales of land by public agencies and has the overwhelming advantage that productive deployment of the underlying resource does not get held up while the Federal Land Commission deliberates, years on end, about each proposed use of real estate.[215] Applying this market-oriented approach to spectrum usage rights would promote similar efficient and effective use.

---

213. *See* NBP 2010, *supra* note 3, at 79, Exhibit 5-C (representing the state of spectrum allocation and historical time lags in administrative proceedings).

214. The "government may also wish to promote the important efficiency and innovation benefits of a spectrum commons by allocating spectrum bands for shared use, much as it allocates land to public parks." SPTFR 2002, *supra* note 1, at 38. The error in this analogy is that the government, with a "public interest" allocation regime for all spectrum uses, pointedly does not allocate unlicensed bands "much as it allocates land to public parks."

215. Coase used the FLC example:

B. LICENSED AND UNLICENSED DEPLOYMENTS IN AN EFFICIENT MIXED USE REGIME

It is sometimes suggested that unlicensed allocations have produced relatively high social value, as well. The use of unlicensed bandwidth indeed provides valuable services, for example, the 2.4 GHz frequencies that support wi-fi connections in wireless local area networks ("WLAN"). Studies have been conducted, including one sponsored by Microsoft in 2009, which purport to estimate the value of the unlicensed allocation by assessing the combined value of the services observed using allocated bandwidth.[216] This methodology is inappropriate because it fails to consider alternatives—either the opportunity cost of the spectrum allocated or the supply of competitive services using a different allocation system.

Perhaps the easiest way to see the problem is to consider the case of broadcast television. The TV Band in the United States today consists of forth-nine channels, or 294 MHz as each channel is allocated 6 MHz by the FCC. Broadcast television stations report annual revenues of about $22 billion, and annual expenditures on TV sets are about $20 billion.[217] As a thought experiment, let us assume that consumer surplus associated with the use of TV sets and broadcast TV content are equal to those amounts: $60 billion annually. But the values of terrestrial TV broadcasting as a distribution

---

> That such would be the consequences of the establishment of a Federal Land Commission is not, I think, open to serious doubt. It is my contention that similar consequences have resulted from the establishment of the FCC. The most detailed enquiries are conducted before a grant is made of a license for the operation of a broadcasting station. The procedures are costly and time-consuming. This is particularly true in comparative hearings in which the FCC often has to choose between claimants, each of whom seems to be about equally well qualified, and between whom therefore the choice has to be based on some quite trivial or even dubious consideration.

Coase, *supra* note 64, at 163.

216. *See generally* RICHARD THANKI, PERSPECTIVE ASSOCIATES, THE ECONOMIC VALUE GENERATED BY CURRENT AND FUTURE ALLOCATIONS OF UNLICENSED SPECTRUM (2009) (study was supported by funding from Microsoft), http://apps.fcc.gov/ecfs/document/view?id=7020039036; Letter from Crag Mundie, Chief Research & Strategy Officer, and Anoop Gupta, Corp. Vice President—Technology Policy & Strategy, Microsoft Corp., to Julius Genachowski, Chairman, FCC (Sept. 21, 2009), *available at* http://apps.fcc.gov/ecfs/document/view?id=7020039035.

217. Fourteenth Video Competition Report, *supra* note 201, at 8708 ¶ 215 tbl.17; Press Release, Consumer Electronics Association, CE Industry to Reach Record-High Revenues in 2012, According to CEA (Jan. 10, 2012), http://www.ce.org/News/News-Releases/Press-Releases/2012-Press-Releases/CE-Industry-to-Reach-Record-High-Revenues-in-2012,.aspx (estimating 2012 U.S. sales of $17.2 billion for HDTV display units, $7.5 billion for 3DTV, $7.7 billion for internet-connected displays).

system and the allocation of spectrum for this service are nowhere near $60 billion. Neither the revenues nor the consumer surplus associated with them depend uniquely on the TV Band's 294 MHz.[218] Over 90% of U.S. TV viewers live in households subscribing to cable or satellite TV, thereby paying for a substitute video delivery platform (which also retransmits off-air broadcast signals), and more importantly, close to 100% of viewers *could subscribe* to cable or satellite TV.[219] Because these competing video distribution systems and emerging broadband networks can replace over-the-air ("OTA") terrestrial television station broadcasts, the social value of the TV Band reflects this prospect of more cost effective alternatives.

The opportunity cost of devoting 294 MHz of prime VHF and UHF spectrum to something other than mobile services easily exceeds $1 trillion.[220] Meanwhile, the ten million U.S. households without cable or satellite subscriptions could be supplied with these technologies[221] at a one-time cost equal to about $3 billion.[222] Hence, even if the consumer surplus generated by TV sets and TV broadcast content is the assumed value of $60 billion annually, the value supplied by the FCC's TV Band spectrum allocation is quite negative.

Similarly, the 2.4 GHz band is useful given its lock-in by regulators, but there are costs to the set-aside. These costs include the social value that could be gained using the 83.5 MHz allocated to the Industrial, Scientific, Medical ("ISM") Band, or some fraction of it, in different ways than those specified

218. In fact, the TV Band was originally 81 channels and 486 MHz between 1939 and 1953, with the digital transition reallocating 108 MHz through auction. *See* Thomas W. Hazlett, *Tragedy T.V.: Rights Fragmentation and the Junk Band Problem*, 53 ARIZ. L. REV. 83, 105, 109 (2011). The white spaces, however, between the remaining channels has not yet changed, pending the incentive auction proceedings authorized in 47 U.S.C. §§ 1451–1452 (2011) (authorizing the FCC to conduct incentive auctions with forward and reserve auction components for broadcast TV spectrum, with a statutory deadline for completion in 2022).

219. Fourteenth Video Competition Report, supra note 201, at 8624 ¶ 37 ("By 2010, cable MVPD service was available to 128.8 million homes (98.5% out of 130.8 million U.S. homes). We assume that DBS MVPDs are available to all homes, but recognize that this slightly overstates the actual availability of DBS."). This proportion is far higher than the percentage of viewers that could obtain their signals directly over the air from a terrestrial station broadcast.

220. *See* Hazlett, *A Proposal for an Overlay Auction*, *supra* note 50, at 5.

221. There is an argument for public safety emergency alerts; the existence of over-the-air ("OTA") broadcasting as a distribution system is not in question as a matter of category, but as a matter of degree and scale. This Article explicitly does not argue for the end of OTA, but the data by which administrative decision makers reallocate the airwaves to alternative uses in a cost-benefit manner.

222. *See* Hazlett, *A Proposal for an Overlay Auction*, *supra* note 50, at 7, with a high estimate that 9.6% of households in 2011 relied solely on OTA television without cable or DBS service. Fourteenth Video Competition Report, *supra* note 201, at 8705–06 ¶ 211.

by the FCC.[223] Moreover, instead of providing additional bandwidth for unlicensed devices, WLANs could be efficiently allocated in spectrum markets. Of course, this alternative relies on the existence of flexible licenses that would permit WLAN technologies to use those airwaves. In this environment, which exists currently for CMRS licenses, spectrum rights could be "bid into" WLAN employments just as such rights allocated bandwidth for cellular networks—Wireless Wide Area Networks ("WWAN"). Indeed, such opportunities are currently available in the market. Instead of lobbying the FCC to put additional bands aside, as did Apple Computer in pushing for a large unlicensed PCS allocation in the 5 GHz band in the early 1990s,[224] device manufacturers could buy (directly, through secondary market deals, or by forming consortia) the spectrum usage rights they demand. This would incorporate price data into the allocation process, with such firms internalizing opportunity costs rather than socializing them via FCC regulation.[225]

In fact, there is little interest in expanding unlicensed bands with liberal frequency rights purchased in the market; the alternatives are too valuable.

---

223. Given the large number of devices and WLANs using ISM frequencies, this is not a proposal but a thought experiment. Once investments have been built around particular rules, transaction costs to transition to alternative allocations also become part of the analysis.

224. *See generally* In the Matter of Amendment of the Commission's Rules to Provide for Unlicensed NII/SUPERNet Operations in the 5 GHz Frequency Range, Notice of Proposed Rule Making, 11 FCC Rcd. 7205 (1996), *available at* http://transition.fcc.gov/Bureaus/Engineering_Technology/Notices/1996/fcc96193.txt.

225. *See* Kwerel & Williams, *supra* note 42, at 31. Because the parties would internalize transaction costs—licensees, equipment makers, and consumers—incentives would be strong to avoid cumbersome payment systems that are more trouble than they are worth:

> Future expansion of dedicated spectrum for unlicensed use could be obtained through negotiation between the manufactures of such devices and spectrum licensees. One possible arrangement would be for a licensee or group of licensees covering a particular band throughout the United States to charge manufacturers a fee for the right to produce and market devices to operate in that band. Such contracts could provide different grades of access for different fees, thus providing for a wider range of uses than are possible under the current rules. Competition between licensees would ensure that fees reflect the opportunity cost of the spectrum. Alternatively, manufacturers of low power devices might form a bidding consortium to acquire additional spectrum in our auction. If there is a continued desire as a matter of public policy to provide spectrum for such devices on a "free" basis, the FCC itself might purchase the spectrum in the auction, essentially reducing overall proceeds to the Treasury. This would have the advantage of making the opportunity cost of such allocations.

Id.

This is important information, more reflective of consumer welfare trade-offs than the evidence proffered in support of additional regulatory set-asides of unlicensed spectrum by firms that hope to use such resources for a price of zero. Indeed, the FCC has made a pronounced policy swing over the past fifteen years, aggressively allocating hundreds of MHz for new unlicensed allocations.[226] But relatively little economic value appears to be generated in these increments,[227] as Coase, Meckling, and Minasian may have anticipated:

> The absence of a market price (which measures the value of a frequency to another user or in another use) means that a user has little idea of when he is using a frequency "wastefully" and no financial incentive to find out. Obviously, a frequency should not be used for a particular purpose if it prevents the accomplishment of greater value . . . . It is clear that such wasteful use must be very common with the existing system.[228]

Hence, it is inappropriate to attribute all of the gross economic activity associated with the use of unlicensed devices solely to the existence of unlicensed allocations. The marginal benefits created by wi-fi connections or cordless phones are properly attributed, in large measure, to the fixed networks to which they connect. The net value that is generated, correctly calculated, reflects both spectrum opportunity costs as well as systemic costs, which arise from the fact that by relying on administrative set-asides of dedicated spectrum blocks for unlicensed uses, the regulatory process is intrinsically tied to a case-by-case allocation system wherein political appointees consider the best way to issue spectrum usage rights. This system, by consensus, produces severe spectrum misallocation, regulatory lags, and disappointing welfare outcomes for wireless consumers.

The complexity of coordinating economic activity over mobile links, where thousands or millions of real property owners may be involved and economies of scale may be national or international in scope, produces a

---

226. *See* Hazlett & Leo, *supra* note 97, at 1047. Unlicensed allocations currently out-allocate licensed ones: "[b]y 2004, the FCC had allocated approximately 665 MHz of spectrum in the same frequency range to unlicensed use. In comparison, as of that same date, about 385 MHz in this range had been allocated to liberal licenses—an unlicensed-to-licensed ratio of 1.7." *Id.* at 1049. "[In December 2008, 240 MHz additional unlicensed spectrum] [b]rought the total unlicensed allocation to 955 MHz. By comparison, as of year-end 2008, approximately 422 MHz had been allocated to liberal licenses, bringing the ratio of unlicensed to liberal-license spectrum to about 2.3 [to] 1." *Id.*; *see also id.* at 1048 n.44; Thomas W. Hazlett, *Spectrum Tragedies*, 22 YALE J. ON REG. 242, 258 fig.2 (2005) ("comparing 648.5 MHz of unlicensed spectrum to 189 MHz of 'flexible use' licensed spectrum").

227. *See* Hazlett & Leo, *supra* note 97, at 1055 (discussing the Starbucks Fallacy).

228. COASE, MECKLING & MINASIAN, *supra* note 37, at 88.

different conclusion for liberal licenses. It is clear that mobile markets could not exist in any form nearly so valuable without "exclusive use" licenses. Indeed, the expression "exclusive use" is a regulatory term[229] revealing deep confusion that illuminates this discussion. The licenses affording exclusive control over frequency spaces give rise to the most valuable wireless services now offered. The spectrum is intensely used and shared by millions of subscribers. Given exclusivity, operators are able and willing to invest aggressively in complementary capital to build platforms for consumer interactivity. This is the standard argument for private property rights: to be optimally cultivated, land requires an owner. The costs of productive investments can now accrue returns for the investors who make them. Network infrastructure, including handsets,[230] is developed with billions of dollars in financial backing to exploit and share the value created via property rights afforded licensees. Exclusive use facilitates spectrum sharing at industry scale.

The nature of spectrum sharing is commonly misconstrued. The unlicensed bands are said to be "[bands that] no one controls,"[231] and facilitate a "spectrum commons."[232] In fact, open access is not the regime governing these bands. Regulators assert authority, licensing the radios permitted to use these frequencies. These restrictions severely limit spectrum sharing, which would, if unrestricted, lead to dissipation of the value of the resource: the tragedy of the commons.[233] The primary regulatory devices are

229. *SPTFR 2002*, *supra* note 1, at 5 ("Exclusive use model. A licensing model in which a licensee has exclusive and transferable flexible use rights for specified spectrum within a defined geographic area, with flexible use rights that are governed primarily by technical rules to protect spectrum users against interference.").

230. Charles L. Jackson, *Wireless Handsets Are Part of the Network*, CTIA (Apr. 27, 2007); Appendix C to Comments of CTIA—The Wireless Association, Skype Communications S.A.R.L., RM-11361 (Apr. 30, 2007), http://files.ctia.org/pdf/Comments_CTIA_Skype_Opposition_Complete_43007.pdf.

231. Yochai Benkler, *Overcoming Agoraphobia: Building the Commons of the Digitally Networked Environment*, 11 HARV. J.L. & TECH. 287, 360 (1998).

232. *SPTFR 2002*, *supra* note 1, at 36, 40.

233. The name is a misnomer, as the paradigmatic 1968 article that gave us this term described it as a "tragedy of open access." Hardin, *supra* note 12. Eggerston explained the confusion:

> In retrospect, the confusion over the nature of common property probably was caused substantially by a mix-up of proper names and theoretical categories. In the field, resources that are governed by open access arrangements often are locally known as "the commons" (or have the word "commons" in their name) because previously they were exclusive common property. The confusion is facilitated by the proximity of open access and common property on the privatization scale. Relatively

(a) power limits, and (b) technology constraints. There are also, in some instances, (c) business model restrictions.[234] The policy strategy is to mitigate potential conflicts via in personam rules, regulations that define what various parties may do with respect to the resource. This is a policy approach distinct from in rem spectrum rights, formulated in liberal licenses, which define a given frequency space and then delegate usage choices to designated rights holders.[235] In particular, the effect of the power limits is to geographically separate users, reducing airwave conflicts by localizing transmissions. By spacing out radios in physical space, these rules create white spaces. In the same way, custom crafted in personam rules necessarily limit the universe of possible sharing combinations.

Of course, wireless networks built by mobile operators—licensees possessing in rem rights—are faced with similar challenges and deploy parallel limiting strategies. They dwell in a maelstrom of conflicting activities that both exacerbate and relieve the basic problem of spectrum scarcity. On the one side, carriers undertake to increase demand for access to the spectrum they control, building networks, distributing or assisting the distribution of mobile handsets, content, and applications—products that add value to the wireless user experience. On the other hand, carriers must ration network access, mitigating congestion while capturing revenues for suppliers, including their own network. This rationing is achieved by a complex set of pricing, service menu, technology and network architecture decisions. For example, carriers may invest in a technology upgrade or network rebuild that triples effective bandwidth for subscribers. But the upgrade is costly and will force the operator to project (a) the net cost of the upgrade relative to the next best capital infrastructure path; and (b) how much customers would pay for the incremental gains, embedding forecasts of price changes, subscriber growth, as well as ancillary revenue streams perhaps made newly available. Competitive market forces drive the operator to seek these particular choice variables, to implement all plans with respect

> small changes in the economic environment can push a common property regime into open access or vice versa.

Eggertsson, *supra* note 12, at 75–76; *see also* David D. Haddock, *Force, Threat, Negotiation: The Private Enforcement of Rights*, *in* PROPERTY RIGHTS: COOPERATION, CONFLICT, AND LAW 168, 185–86 (2003) (discussing the role of government force to enforce rights when private rights are unavailable).

234. Many countries (e.g., Mexico, the United Kingdom) have limited wi-fi use in the 2.4 GHz band, e.g., to noncommercial operations. Widespread noncompliance resulted from this restriction.

235. *See generally* Thomas W. Merrill & Henry E. Smith, *What Happened to Property in Law and Economics?*, 111 YALE L.J. 357 (2001).

to the most efficient pathways, and to execute only those choices that promise to produce net gains. In a dynamic world, the optimization parameters continually change, making the search for "optimal combinations" an endless pursuit.

C. RULES TO ENABLE MARKETS

Coase argued, ex ante, that spectrum ownership, as opposed to administrative allocation, would steer this "optimal combinations" process in a more efficient direction.[236] Current data from the performance of mobile markets, using liberal licenses and de facto spectrum ownership rights issued long after Coase wrote, coupled with ongoing stasis in traditionally regulated markets such as radio and TV broadcasting, strongly endorses this positive prediction and normative proposal. But, the more subtle implication relates to the definition of harmful interference in radio spectrum rights. Indeed, Ronald Coase's core insight in his 1959 and 1960 papers was that interference between resource users, including wireless operators, was the primary concern.[237] Conflicts were ubiquitous in the economy—Coase did not use the phrase "externality," popular with economists when discussing the topic—and the generic question did not change with so-called "spillovers." That question was: how to select which resources have the most value given conflicting and mutually exclusive demands? Government administrators enjoyed comparative advantage in some social activities, but not in discovering or acting upon the information needed to make choices between alternative uses for spectrum. The task, therefore, was to secure rules governing radio spectrum use that would allow private, profit-seeking enterprises to improve upon the choices state allocation authorities would make. This task included questions governing "interference."

The rules shifting resource allocation choices from public to private actors need not be perfect. Since administrative allocation is a costly system of creating use rights, the process delegating such choices instead to markets may also prove costly, and yet remain superior to government allocation. As the late, great, regulatory economist Alfred Kahn once said: "[W]herever it seems likely to be effective, even very imperfect competition is preferable to regulation."[238] Law professor Richard Epstein puts the point more broadly:

236. COASE, MECKLING & MINASIAN, *supra* note 37, at 23.

237. *See* Coase, *supra* notes 44, 156.

238. 1 ALFRED E. KAHN, THE ECONOMICS OF REGULATION: PRINCIPLES AND INSTITUTIONS xxiii (1988) (citing 2 ALFRED E. KAHN, THE ECONOMICS OF REGULATION: PRINCIPLES AND INSTITUTIONS 112, 328–29).

"The study of human institutions is always a search for the most tolerable imperfections."[239]

The relevant task is, then, to enable wireless markets to maximize output rather than to minimize interference.[240] In this effort, we should expect there to be many conflicts between users, and even potential users. But, in defining resource rights such that utilization choices are made by responsible economic agents, greater efficiencies result than in alternative regimes. Today, the rules for such a system need not be conjured from whole cloth. They are best designed by building upon existing frameworks. Indeed, this is an advantage that scholars such as Coase (1959), De Vany et. al. (1969), and Minasian (1975)[241] did not enjoy.

As a technical legal matter, rights to radio spectrum cannot be *owned*—either by the government or by private parties. The airwaves are said, as per the 1927 Radio Act, to belong as public convenience, interest, or necessity requires. As such, the Federal Radio Commission and, since the 1934 Communications Act, the Federal Communications Commission ("FCC"), have been given authority to regulate all uses of spectrum so as to protect the "public airwaves."[242] Yet, by moving from operating permits to defined spectrum spaces, authorizations that permit flexible use of the airwaves allocated the license, U.S. regulators create de facto private property rights in spectrum.[243] Since the 1993 federal budget authorized the use of competitive bidding for most FCC licenses, the liberalized rights to exclusively control frequency spaces have been auctioned; since 1994, over 30,000 licenses have

239. SOWELL, *supra* note 14, at 96 (quoting RICHARD A. EPSTEIN, OVERDOSE: HOW EXCESSIVE GOVERNMENT REGULATION STIFLES PHARMACEUTICAL INNOVATION 15 (2006)). Of course, this view could be appropriately cited to Harold Demsetz, *Information and Efficiency: Another Viewpoint*, 12 J.L. & ECON. 1, 1–4 (1969), which employed the descriptive phrases "nirvana view" or "nirvana approach" to clarify the situation. Today, the phrase "Nirvana Fallacy" merits its own Wikipedia entry. *See Nirvana Fallacy*, WIKIPEDIA, http://en.wikipedia.org/wiki/Nirvana_fallacy (last visited July 15, 2012).

240. "It is sometimes implied that the aim of regulation in the radio industry should be to minimize interference. But this would be wrong. The aim should be to maximize output." Coase, *supra* note 156, at 27. Taken out of context, this passage has often been misinterpreted. Coase makes clear, both in this paper and in his "Social Cost" article the following year, that economic policy must aim not at determining the right particulars in a given case, but to devise institutions that most reliably discover and implement such solutions over time.

241. Coase, *Federal Communications Commission*, *supra* note 156; De Vany, *supra* note 38; Minasian, *supra* note 72.

242. *Wireless Craze*, *supra* note 30, at 359–61; Radio Act of 1927, Pub. L. No. 69-632, 44 Stat. 1162 (1927).

243. These rights are labeled "exclusively assigned, flexible–use spectrum" (EAFUS) rights in Hazlett & Spitzer, *Advanced Wireless Technologies*, *supra* note 196, at 596.

been assigned and some $52 billion collected by the U.S. Treasury in winning bids.[244]

In thinking about defining rights to best handle the problem of harmful interference, these newer regulatory models are of prime importance. In general, property rules evolve over time, shifting in response to changes in demand, technology, population, and resource scarcity.[245] Indeed, when resources have limited value, it is often not worth defining rights—whether for state ownership, private property, or a commons—if the process of creating and enforcing such rules entails significant cost. As circumstances change, these trade-offs will likewise change, such as when the introduction of barbed wire in the 1870s allowed cheaper enforcement of private land rights on the Great Plains.[246] This precipitated a trend by homesteaders to use fencing material to separate crops from "invading cowboys and their herds," and by cattlemen, to enclose their accustomed range.[247] The definition of land for livestock grazing, crop cultivation, and later, the transcontinental railroads, would transfer much of the government "unclaimed communal property" to "private hands."[248]

244. Thomas W. Hazlett, David Porter & Vernon Smith, *Radio Spectrum and the Disruptive Clarity of Ronald Coase*, 54 J.L. & ECON. S125 app. tbl. A1 (2011) [hereinafter Hazlett et al., *Disruptive Clarity*].

245. *See generally* Harold Demsetz, *The Exchange and Enforcement of Property Rights*, 7 J.L. & ECON. 11 (1964); Demsetz, *supra* note 60.

246. Terry Anderson & Peter J. Hill, *The Evolution of Property Rights: A Study of the American West*, 18 J.L. & ECON. 163, 172 (1975).

247. *Id.* at 172 (describing how in 1882 the Frying Pan Ranch in Panhandle "spent $39,000 erecting a four-wire fence around a pasture of 250,000 acres."); *see also Frying Pan Ranch*, TEXAS STATE HISTORICAL ASSOCIATION, http://www.tshaonline.org/handbook/online/articles/apf03 (last visited July 25, 2012) (describing how in 1887 the Fort Worth and Denver City Railway ran "diagonally through the ranch from southeast to northwest").

248. Anderson & Hill, *supra* note 246, at 172. The increase in the value of land and property rights definitions increased along with productive and population activity:

> But the growing demand for land by cattlemen, sheepherders, and grangers eventually caused the value of land to increase and hence increased the benefits from definition and enforcement activity [in range rights] . . . . These rights provided some exclusivity over use in land, but as population increased (see Table 1) [Population of the Great Plains 1850–1900, from 274,139 to 7,377,091], settlement became more dense and land values rose even more. Individuals and groups began devoting more resources toward the definition and enforcement of private property rights.

Id. at 170 (footnote and table omitted).

The development of property rights for private cultivation is incremental, just as it was in the American West.[249] Some see the rights definition problem in spectrum as a task that will create a whole new policy regime—or accuse unnamed others of seeing things this way. John Berresford and Wayne Leighton, two FCC analysts writing in 2004, stated:

> We agree that if property law is in fact more efficient than spectrum law, then making spectrum more property-like will improve efficiency. To talk of scrapping present spectrum law and replacing it with "property rights," however, is to throw the baby out with the bathwater.[250]

But no babies are being tossed. Whether existing spectrum law could be wholly replaced by an entirely new system of rights is an interesting question to ponder. It is not, however, a question worth expending resources upon. Given the broad push towards liberal licenses, existing templates for de facto spectrum ownership are already available in the United States and elsewhere. There are varying programs for further liberalization that might be considered, none of which entail destroying existing rights in order to start from scratch—a process that entails vast disruptions and, in any case, is very unlikely to happen. The contemplated programs of liberalization include regulator-driven initiatives, as undertaken by Ofcom in the United Kingdom in 2002–2004;[251] legislative reforms as instituted in Australia, New Zealand, Guatemala, and El Salvador in the 1990s;[252] and an extension of liberal

249. *Id.* at 172 ("During the 1870's and 1880's many acres were privately claimed under the homestead, preemption, and desert land laws. And finally, land was granted outright to the transcontinental railroads who in turn transferred much of it into private hands.").

250. John Berresford & Wayne Leighton, *The Law of Property and the Law of Spectrum: A Critical Comparison*, 13 COMMLAW CONSPECTUS 35, 37 (2004). We are not aware of any scholars who argue that the entire legal/regulatory regime for radio spectrum should be scrapped, and none are cited in the article cited. This includes Peter W. Huber, author of LAW AND DISORDER IN CYBERSPACE: ABOLISH THE FCC AND LET COMMON LAW RULE THE TELECOSM (1997). It also includes, obviously, Thomas W. Hazlett, the co-author of this Article, author of *Optimal Abolition of FCC Spectrum Allocation*, 23 J. ECON. PERSP. 103 (2008) [hereinafter Hazlett, *Optimal Abolition*]. Both of these works explicitly rely on existing de facto property rights exercised by spectrum users, and the legal templates defining them, as the basis for moving forward with further reforms.

251. Martin Cave, *Independent Audit of Spectrum Holdings: Final Report*, *An Independent Audit for Her Majesty's Treasury*, SPECTRUMAUDIT (2005), *available at* http://www.spectrumaudit.org.uk/pdf/caveaudit.pdf; Ofcom, *The Communications Market 2006 Overview*, at § 1.6.4, (2006), http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/cm06/overview06/spectrum/ (authorizing spectrum trading in 2004, with the first spectrum trades in 2005–2006); Ofcom, *Simplifying Spectrum* Trading, http://stakeholders.ofcom.org.uk/consultations/simplify/statement/ (refining proposals from September 2009 consultation on how to streamline market liberalization).

252. Hazlett, *Wireless License Values*, *supra* note 72, at 582–86.

models, such as overlays rights, developed by regulators but deployed parsimoniously, which form a central feature of the policy solution proposed in this Article.[253]

D. OBSERVED EFFICIENCIES IN EMERGING SPECTRUM MARKETS

In defining property rights, various methods of social coordination immediately come into play. Indeed, a basic advantage resulting from the creation of in rem rights is the production of low-cost enforcement information for all members of society—both owners and non-owners. The rights and responsibilities associated with ownership are fairly well understood, such that individuals can ascertain how to interact, either from cooperating in a trade or in respecting each other's rights by not trading. Thomas Merrill and Henry Smith find that shared understandings of ownership help explain why property forms are limited in number, while contractual terms are essentially infinite—agreements specifying anything signatories to the bargain decide to include.[254] The information contained in the former must spread to large numbers of parties, while the latter are relevant to only a small number of well-informed parties.[255]

The essential reason for creating a regime of property-like ownership rights in spectrum, perhaps better seen as a transition from in personam to *in* rem rights, or from "governance" to "exclusion,"[256] is to better control harmful interference. Here we diverge from the usual case for this reform, which is to expand the economic benefits generated from wireless services. Yet the original proposal for this reform, from Ronald Coase, was developed to resolve the problem that we deal with here: how to best define usage rights in spectrum so as to mitigate harmful interference.[257] The original justification for administrative allocation, as retold by Coase, was that, without administrative control of all airwave use, endemic conflicts would destroy the value of radio spectrum, unleashing "chaos,"[258] "etheric bedlam,"[259] or a "cacophony of competing voices."[260] Coase saw that this was

253. *See infra* Section IV.K.

254. *See* Merrill & Smith, *The Property/Contract Interface*, *supra* note 18, at 778.

255. *Id.*

256. Henry E. Smith, *Exclusion Versus Governance: Two Strategies for Delineating Property Rights*, 31 J. LEGAL STUD. 453, 456 (2002) (explaining that "[f]or low levels of precision, the marginal cost of exclusion is low but increases rapidly with higher levels of precision; the marginal cost of governance rules may be higher than for exclusion rules but may increase less rapidly.").

257. Coase, *supra* note 156, at 34–35.

258. Nat'l Broad. Co. v. United States, 319 U.S. 190, 213 (1943).

259. Coase, *supra* note 156, at 2 (citing 2 S. Rep. No. 659, at 4 (1910)).

260. Red Lion Broad. Co. v. FCC, 395 U.S. 367, 376 (1969).

not the case. The cited interference issues were solved by a system of use restrictions, which could either be applied top-down by regulators or, alternatively, by delimited rights issued to private parties. Coase's preference for market competition and its efficiency properties led him to favor the latter approach—subject to empirical verification that its net benefits did, in fact, exceed those of administrative allocation.[261]

So, the "choice of the optimal regime" is, in essence, just the policy margin to which investigating how to resolve harmful interference leads. It should be noted that Coase partially changed his mind. While Coase argued initially for private ownership of spectrum in his 1959 article, analogizing spectrum to land and markets in real estate,[262] he later detoured:

> What does not seem to have been understood is that what is being allocated by the Federal Communications Commission, or, if there were a market, what would be sold, is the right to use a piece of equipment to transmit signals in a particular way. Once the question is looked at in this way, it is unnecessary to think in terms of ownership of frequencies or the ether.[263]

As Merrill and Smith noted in 2001,[264] this approach is highly inconsistent. The very process whereby the regulator issues parsimonious use rights, determining how "a piece of equipment [may] transmit signals" is what nests choices regarding economic trade-offs with dispassionate regulators instead of profit-seeking entrepreneurs.[265] The costs and benefits that Coase aims to internalize via property institutions are truncated; more efficient technologies, services, or business models are deployed only at the discretion of regulators. To argue for market allocation of spectrum is to bypass this system of restrictions and obviate the need for bureaucratic permissions.

More poignantly, the problem with in personam rights in spectrum is that the process by which the regulator defines each new right under a "bundle of

---

261. At the time, Coase was convinced not by empirical evidence, but by his understanding of Adam Smith's "invisible hand" (tending to recommend market competition), and by the "incredibly feeble" arguments put forward against it by defenders of the existing regime. *See* Ronald H. Coase, *Law and Economics at Chicago*, 36 J.L. & ECON. 239, 249 (1993).

262. "We know from our ordinary experience that land can be allocated to land users without the need for government regulation by using the price mechanism. But if no property rights were created in land, so that everyone could use a tract of land, it is clear that there would be considerable confusion . . . ." Coase, *supra* note 156, at 14.

263. Coase, *supra* note 156, at 33.

264. Merrill & Smith, *supra* note 235.

265. Coase, *supra* note 156, at 33.

sticks" approach, such as when a new wireless technology becomes available, is expensive. Administrative procedures at the FCC are famous for putting the burden of proof on competitive entrants, for sponsoring rent seeking rivalries that create and distribute supra-competitive profits on behalf of politically influential interests or constituencies, and for reliably sacrificing the consuming public's interest in technological innovation and business competition. By shifting from a defined bundle of explicit spectrum use rights to in rem ownership, economic incentives are redirected to discover and deploy the very options that cannot be known ex ante. Such spaces will no doubt be imperfectly defined, but the prospect that improvements will flow from expanding the bundles of rights to include *all* the productive activities that licensees can deploy within such definitions is the proper goal and the observed outcome of liberalization that takes spectrum rights from "governance" to "exclusion."[266]

There are no pure property rights.[267] Property borders are always subject to some degree of fuzziness, and enforcement of defined interests are inevitably subject to some level of stochastic deviation. Contracts, in which property is reconfigured and rights are traded, are likewise incomplete, reflecting efficiencies internalized by the parties to the contract.[268] The law allows that landowners must accept trespass in some situations, for example, when an emergency drives an incursion that is incidental and does not allow for a properly negotiated agreement.[269] When air travel developed in the early twentieth century, the rights of landowners to enforce their equity interests

266. *See* Smith, *supra* note 256, at S462. Smith discussed the Demsetz thesis in the open-field period of England: "Under the Demsetz thesis, the trend toward enclosure reflects increased land value leading to more exclusive rights." Smith continues his discussion of the Demsetz model: "One initial take on the evolution of property rights is to focus on the costs and benefits of defining and enforcing them. Demsetz proposed that property rights are devices to internalize externalities and will develop when the gains of internalization outweigh its costs." *Id.*

267. Smith, *Property as the Law of Things*, *supra* note 18, at 1706 ("More generally, situations between the fully in rem and the fully in personam present themselves, and a preliminary inquiry reveals that intermediate situations are handled with less formalism and less rigid standardization than in rem situations but do not allow the degree of customization possible in contract law. As Thomas Merrill and I have shown, in rem rights avail against many parties, and those duty holders tend to be anonymous or indefinite."); *id.* at 1707 ("In situations falling between in personam and in rem, we tend to find intermediate levels of mandatoriness and standardization.").

268. RICHARD A. POSNER, ECONOMIC ANALYSIS OF LAW 118–19 (8th Ed. 2011) (explaining that "[a]djudicative gap-filling is a particularly economical method of dealing with contingencies that, even if foreseeable . . . are so unlikely . . . that the costs of careful drafting to deal with them exceed the benefits").

269. *Id.*

high in the sky was truncated by legislation. The solution was efficient. In determining what rights are properly included in the ownership package, priority is given to highly complementary rights that are most productively used in an integrated fashion.[270] The fly-over routes of airplanes are inefficient, and cannot be efficiently integrated with the land parcels underlying them, given the large number of property owners involved.[271] The rights create inefficiencies, and therefore, they are split.[272]

Consider the case of property owners sitting atop petroleum reserves. While these landowners benefit society in owning such resources, and thereby seek to economically supply them to consumers, it is prohibitively costly to define the precise, or even approximate, parameters of the underground pools and attribute the subsurface resource rights to landowners (or other owners). Instead, such resources are discovered over time. When oil is found, reserves must be jointly pumped—in any situation where multiple surface owners are located over the pool—with explicit coordination between owners. Otherwise, an inefficient race to dissipate the resource is ignited. Property rules, called "unitization,"[273] developed to define the private property rights to petroleum.[274]

With radio spectrum, one must first ask whether spectrum rights should be separate from real property. A landowner might claim ownership of the airwaves in the aerial cone defined by land surface rights. Some spectrum analysts have actually argued for such a system.[275] The approach would clearly deprive society of highly valuable opportunities for communications services. Were wide-area networks ("WAN"), such as mobile phone systems,

---

270. Smith, *Property as the Law of Things*, *supra* note 18, at 1703 ("Property clusters complementary attributes—land's soil nutrients, moisture, building support, or parts of everyday objects like chairs—into the parcels of real estate or tangible and intangible objects of personal property. It then employs information-hiding and limited interfaces to manage complexity.").

271. Smith, *supra* note 65, at 1746 n.6. ("*cujus est solum, ejus est usque ad coelum et ad inferos* (he who owns the soil owns also to the sky and to the depths)").

272. *See infra* note 287; Smith, *Property as the Law of Things*, *supra* note 18, at 1721–22 (citing Henry Hansmann & Reinier Kraakman, *The Essential Role of Organizational Law*, 110 YALE L.J. 387, 390 (2000)) (discussing asset planning).

273. Gary D. Libecap & James L. Smith, *The Economic Evolution of Petroleum Property Rights in the United States*, 31 J. LEGAL STUD. S589 (2002) (examining how property rights develop when the benefits exceed the costs of doing so, in the case of unitization, a common-pool property arrangement in subterranean oil and gas extraction).

274. Gary D. Libecap, *Contracting for Property Rights*, *in* PROPERTY RIGHTS: COOPERATION, CONFLICT AND LAW 142–67 (2003).

275. J.H. Snider, *FCC Lets the Telecom Giants Steal from You, Via Eminent Domain, Fat Cat Donors Get Airwaves—Worth Billions—In Our Homes*, SACRAMENTO BEE, Apr. 7, 2002, http://www.newamerica.net/node/6856.

forced to negotiate with thousands of landowners in order to provide regional or national wireless services, it would undermine productive activity, similar to the airline fly-over example. It would be far better if the rights for spectrum are, in general, split from the control of landowners.

However, there are spectrum cases where the rights of real property owners should matter. For extremely low-powered emissions, usage is necessarily quite localized as weak signals do not tend to travel far. Coordinating with conflicting users is not so complex as with higher-powered, longer-distance emissions.[276] On the other hand, defining and enforcing wide-area rights down to such levels is expensive. At some very low power level, the effort of defining these rights is not likely to be worth the cost. Radio-based networks are engineered to avoid, by and large, use of the "noise floor" which hosts such very low-powered emissions and a host of atmospheric and topographic obstacles.[277] So, the efficient policy is to define exclusive ownership rights over higher power levels across wide geographic areas (local, regional or national), accommodating the emissions generally deployed in such networks while ceding property owners control over very low-powered emissions that peacefully co-exist beneath the wide-area communications traffic. Such use of localized, very low-powered wireless devices need not be formally recognized by easements, but simply embedded via limitations placed on the rights authorized for wide-area licenses.

There is considerable interest about the need to construct or assign spectrum rights such that transmission rights can be assigned with real-time coordination.[278] This interest is often driven by the emergence of cognitive radios capable of scanning the radio environment and opportunistically using frequency spaces that are temporarily vacant. This desire to utilize under-utilized spectrum space is quite understandable given the nature of the spectrum allocation system, a regime that routinely blocks productive wireless activity. But the approach taken, nesting rules for opportunistic spectrum sharing in the same regulatory system that has under-allocated rights to begin with, is dubious given that there is a demonstrably superior mechanism for rights allocation.

That mechanism is the market allocation of spectrum capacity found in the mobile market. With liberal licenses, carriers routinely allocate spectrum minutes to a large variety of networks, customers, and application providers.

276. SPTFR 2002, *supra* note 1, at 19.

277. *Id.* at 25 n.47 (describing the engineering of radio devices with operational specifications of signal-to-noise ratios).

278. *See, e.g.*, Forde & Doyle, *supra* note 41.

Retail subscribers purchase access to the carrier's spectrum along with network access for a monthly fee (post-paid contracts) or by purchasing minutes of use (pre-paid contracts).[279] Wholesale subscribers, including MVNOs or system aggregators facilitating M2M applications, purchase spectrum and network access for millions of minutes of monthly usage.[280] Application providers, including handset vendors, strike contractual bargains with networks allowing their customers to obtain wireless connectivity from a particular carrier.[281]

In this manner, spectrum is intensely shared, but the nature of the contractual forms shows how efficient these forms are. Deals are, with an important exception, universally *bundled*: spectrum access is sold in a package with network access. Naked spectrum access—possibly with the set-aside of a certain frequency band for use by devices that do not access the mobile operator's network—is not sold directly to the consumer. The exception is that naked, unbundled spectrum rights do trade, actively, in license markets. These are often called "secondary markets." However, the term can be applied far more broadly in that operators are in the business of (a) acquiring bandwidth via wireless license rights, aggregating those rights into efficient combinations through initial bids in auctions and then purchases in secondary markets; (b) cultivating the value of the acquired bandwidth via the construction of complementary networks and mobile services ecosystems; and then (c) reselling the spectrum rights, bundled with network and ecosystem access.[282]

Are spectrum rights sold dynamically? Yes and no. Retail and wholesale customers typically access networks on demand, using long-term contracts. Quality of Service ("QoS") is a key competitive metric; when network services are unavailable (e.g., blocked or dropped calls, slow data throughput) carriers tend to lose market share to rivals, enforcing competitive incentives to improve QoS.[283] Many of the services offered are "free" on a per-unit basis. After paying a fixed entry fee (monthly subscription price), on-net or

279. Fifteenth Annual Competition Report, *supra* note 20, at 9767 ¶ 167.

280. *Id.* at 9756 ¶ 150, 9785 ¶ 195.

281. *See* Hazlett & Leo, *supra* note 97, at 1089.

282. *See, e.g.*, Press Release, Inmarsat, N. America Spectrum Deal Signed with SkyTerra and MSV (Dec. 21, 2007), *available at* http://www.sec.gov/Archives/edgar/data/756502/000114420407068694/v097951_ex99-1.htm (describing the "re-banding and efficient reuse" of licensed L-Band spectrum, with "Coordination parameters for the parties' next generation satellites covering North America, both the new Inmarsat-4s and the new MSV1 and MSV2 satellites, in a manner designed to increase spectrum efficiency.").

283. *See* Fifteenth Annual Competition Report, *supra* note 20, at 9758 ¶ 156.

off-peak phone calls or text messages are uncharged.[284] Mobile network data consumption and peak voice calls are usually "free" to a cap, then limits take effect or overage charges apply.[285]

Were there sufficient demand for commoditized spectrum access for opportunistic devices to justify its opportunity cost, networks would sell it and customers would buy it. Indeed, many of the devices that currently access networks—from Kindles (for book downloads) to OnStar (for emergency phone calls) to dongles (yielding broadband connections for notebooks)—are analogous from the consumer's perspective to plug-and-play radios that operate via direct access to broadcast spectrum.[286] It is perfectly legal to extend the carriers' models to accommodate cognitive radio access directly by consumers. A compelling hypothesis explaining why such deals have, in the main, not emerged is this: There are great efficiencies in vertically integrating wireless networks with spectrum ownership rights. While thousands of investors and millions of customers may pay to create and then operate such systems, leaving control in the hands of one for-profit enterprise reduces complexity. Borders are reduced, and border disputes eliminated. Instead of a firm aggregating a national swath of radio spectrum rights and then selling access to multiple parties in the form of naked spectrum rights, the market iterates on a model that cross-subsidizes spectrum and networks under common ownership, and then divvies up total value into discrete bundles of spectrum and network service.

In this sense, commoditization of spectrum rights is not an efficient outcome, as opposed to bundled rights. Commoditized spectrum, except perhaps in very localized applications best served by unlicensed spectrum set-asides, has little value to users relative to spectrum inputs with network access. The difference is large enough to provide an incentive for carriers to create and build those networks; it would not be their first choice, in terms of profit maximation, to construct such costly accouterments.[287] Because competitive forces constrain the networks to efficient operations, they are not able to command profit-maximizing returns without integrating into both ends of the business and selling both wholesale and retail customers bundled packages.

284. *Id.* at 9724–25 ¶ 82.

285. *Id.* at 9725 ¶ 83.

286. *Id.* at 9754–55 ¶ 146.

287. Smith, *Property as the Law of Things*, *supra* note 18, at 1721–22 (discussing bundles of abstract rights in entity property of sophisticated contracts, equitable property as trusts, and financial instruments, with the efficiencies of asset partitioning as a higher-level modularization of resources).

The important implication is that exclusive spectrum rights should not be over-defined. To help create secondary markets, some advocate that spectrum rights be divided into tiny increments[288] in frequency space, area, time, or in additional dimensions such as altitude (height above adjacent terrain) or directionality (signals beamed at different angles producing distinct, non-interfering communications links), as discussed in the next section. Indeed, there are an infinite number of possible spectrum packages that could be devised. But the goal of rights definition is not to maximize the customization of possible parcels, but to simplify the process wherein rights are transferred to parties who can best maximize social value—a rule that also applies when seeking the parties in the best position to design the packages.[289] Should the state have a comparative advantage in this respect, it would make economic sense to have regulators supply this design. But the evidence is overwhelming that this is not the case. Government usage definitions have historically been poorly designed and, even worse, rigid. Markets, given a chance to reallocate the spectrum allocated to mobile licenses, have proven adept at devising efficient models to create new wireless services, and at adjusting business models as innovative applications and more advanced technologies become available.

However, one very important point is made in the dynamic access model presented by engineers Tim Forde and Linda Doyle. Arguing for the release of small, flexible-use spectrum blocks, they limit the definitions of these blocks to three dimensions, adopting the TAS rights of De Vany et al. (1969).[290] They also include, as an integral part of their proposal, an auction "for the IPO-like release of spectrum licenses,"[291] giving market competitors an opportunity to aggregate such rights into far larger blocks, presumably (from observing how mobile markets work) dictated by efficiency. Indeed, they propose a combinatorial clock auction,[292] a mechanism designed to

288. MATHESON & MORRIS, *supra* note 56, at 8; *see supra* note 74 and accompanying text; Coase, *supra* note 156, at 33.

289. Smith, *Property as the Law of Things*, *supra* note 18, at 1708 (citing Smith, *Standardization in Property Law*, *in* RESEARCH HANDBOOK ON THE ECONOMICS OF PROPERTY LAW) ("Modularity and its standardization of the 'outsides' of property packages allow achievement of a wide range of objectives (lowering frustration costs), while keeping information costs under control, relative to a system of more tailored packages.").

290. De Vany et al., *supra* note 38, at 1501.

291. Forde & Doyle, *supra* note 41, at 329.

292. *Id.* at 329 fig.3 (describing the general clock mechanism with the following auction components: reserve, post prices, bid, excess, tick, and assignment). They propose a combinatorial clock auction for network-based access. *Id.* at 332. Take note that the authors suggest the clock auction "is not itself 'cognitive' [but] the mechanism can be optimally exploited by cognitive participants." *Id.* at 332–33. This result is implicated by the exclusive

facilitate the efficient valuation and aggregation of highly complementary rights, applied perfectly to the assets being distributed here.[293]

The elements of efficient spectrum markets are thus found in the Forde-Doyle proposal: liberal spectrum licenses, allowing responsible economic parties to internalize the costs and benefits of alternative spectrum use, are a ready mechanism for overcoming inefficient rights fragmentation in the initial creation or distribution of such rights.[294] The key policy issue revolves around the cost of government parcelization of spectrum blocks in combinatorial auctions that allow bidders to selectively aggregate rights into efficiently-shaped packages that winning bidders are then free to disaggregate, versus a more cumbersome approach where packages are defined by regulators.[295] That U.S. regulators have proven unable to conduct

---

rights foundation for bidders. *Id.* For a general overview of combinatorial clock auctions, see David Porter & Vernon Smith, *FCC License Auction Design: A 12-Year Experiment*, 3 J.L. ECON. & POL'Y 63 (2006). Combinatorial auctions allow a licensee to bid for "packages of licenses," *id.* at 74, rather than pre-arranged combinations:

> [B]idders are not able to make bids such as 'I want License B *and* C together or neither.' Not allowing "*and*" bids handicaps bidders who have regional or national business plans. Combinatorial auctions allow for such bidding possibilities. In addition to *and* bids, combinatorial auctions allow for "*or*," "*only if*" and other logical bid constraints.

Id. (emphasis in original). Porter & Smith also provide revenue per auction per year data from FCC spectrum auctions that did not apply combinatorial bidding and had varying results. *Id.* at 78 figs.1–2. Strategic bidding behaviors included new terms as jump bidding, up yourself, retaliatory bids, parking, eligibility management, lateral hand-off, bid and waive, trailing digits, and budget bluffing. *Id.* at 71–72. Recommended improvements to auction design included click-box bidding, limit withdrawals, increment smoothing, among structural changes by way of combinatorial auctions which would allow bidders to select the complementary bundles of licenses. *Id.* at 73–74.

293. As Ford & Doyle explained:

> Combinatorial auctions are very useful when there are a range of items on sale which may be logically grouped together into many different packages to suit either the buyer, the seller or both. One of the main benefits of combinatorial auctions is that they reduce the financial exposure of the traders, i.e. a buyer will either get to buy all of its target package or none of it.

Ford & Doyle, *supra* note 41, at 331. The FCC endorsed the combinatorial bidding format in a May 2000 conference of prominent economists. FCC, *May 5–7, 2000 Combinatorial Bidding Conference*, http://wireless.fcc.gov/auctions/default.htm?job=conference_agenda&y=2000 [hereinafter *2000 Combinatorial Bidding Conference*].

294. Forde & Doyle, *supra* note 41, at 332 (comparing the access mechanism as more like a "commodities market" with session to session trades, rather than an "initial-public-offering style trading").

295. *2000 Combinatorial Bidding Conference*, *supra* note 293; Porter et al., *supra* note 144; COMBINATORIAL AUCTIONS (Peter Cramton, Yoav Shoham & Richard Steinberg, eds., 2006) [hereinafter COMBINATORIAL AUCTIONS].

auctions with serious combinatorial bidding options, despite having professed interest in adopting the approach for well over a decade,[296] suggests that administrative costs today may be relatively high.

E. MOBILE OPERATORS AS SPECTRUM OWNERS AND NEIGHBORS

The solution to harmful interference is worked out with little fanfare in markets where liberal licenses are issued and firms are free to aggregate rights by secondary market trading. The natural tendency is to then use mergers to eliminate borders. Without the 40,000-plus CMRS licenses owned by Sprint Nextel, wireless services provided by the carrier or carriers deploying the same bandwidth would have to account for the spillovers that might occur across boundaries, both in the geographic and frequency dimensions.[297] Without aggregated licenses, coordination would be extensive and complex. Moreover, economies of scale in provisioning networks—from volume discounts in the purchase of infrastructure and handsets, to construction of a national network complete with roaming capability for subscribers, to marketing in national media outlets—would be sacrificed. All of these forms of harmful interference are overcome via rights aggregation.

Merger is not free, however. It costs a firm to manage a larger asset base, and not all such costs will be subject to scale economies. Firms tend to engage in such mergers only when the advantages of a merger exceed the disadvantages. Profit incentives, including capital market liquidation of poorly managed firms that botch the cost-benefit calculus, govern the process. No such feedback loop is available in the public sector. Regulators routinely disaggregate licenses, producing band plans with expensive borders, managing spillovers by "guard bands," technology, or service restrictions.[298] Guard bands leave spectrum fallow to protect traffic in neighboring frequencies. The overuse of such techniques is well documented, most dramatically in the use of "taboo" channels that have dominated the TV

296. *2000 Combinatorial Bidding Conference*, *supra* note 293. Through 2011, however, the only combination bidding allowed in an FCC auction occurred in Auction 73 (for 700 MHz licenses) and only allowed package bids that aggregated the largest (Regional Economic Area Grouping REAG licenses) in Block C. *See* Hazlett et al., *Disruptive Clarity*, *supra* note 244, at S145 n.39.

297. *See* discussion *supra* Section III.E (on Nextel Spectrum Swap); FCC Adopts Solution to Interference Problem Faced by 800 MHz Public Safety Radio Systems, News Release, FCC, July 8, 2004; *Fifteenth Wireless Competition Report*, *supra* note 20, at Appendix A ¶ 6, *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-249414A1.pdf.

298. *Fifteenth Wireless Competition Report*, *supra* note 20, at Appendix A ¶ 10 n.26 (citing 700 MHz Second Report & Order, 22 FCC Rcd. at 15,292–93, ¶ 3) (describing the modification of 700 MHz guard bands, to reallocate uses to commercial spectrum) (Appendix text only available at FCC website).

Band for its entire existence.[299] Given that regulators bear no cost for under-allocations yet receive strong political support for overprotecting incumbents (both from the licensees and from politicians who see the regulation-created rents as a platform for launching various demands for quid pro quo commitments by licensees), economists are not surprised by the scope of the anti-consumer outcomes.[300]

While most of the "interference" problem in liberally allocated spectrum is efficiently remedied via rational choices enabled by flexible-use and secondary market options, the borders that remain, even following license aggregation, are typically well behaved. That is, when two wireless operators, each possessing liberal spectrum rights, share a frequency border, the outcome does not generate much legal or administrative conflict. With flexible use rights, parties internalize the costs of both signal degradation and haggling. In any given interference issue, the parties involved are highly motivated to fix the problem, cooperating to create gains, which are then split between them by agreement.[301] Of course, there can always be acrimony over such skirmishes: who incurs costs, and who then pays what to compensate.

Again, mobile markets supply the relevant empirical data. In an interesting analysis, Verizon Wireless executive Charla Rath has noted that her firm owns "more than 1500 mobile licenses, not to mention thousands more microwave licenses."[302] While this eliminates countless potential border disputes, it does not eliminate the possibility of such disagreements entirely. Indeed, given the large stakes involved in serving "nearly 100 million customers," in theory, the borders Verizon Wireless continues to share with

299. NBP 2010, *supra* note 3, at 79 ("Legacy 'command and control' rules, high transaction costs and highly fragmented license regimes sometimes preserve outmoded band plans and prevent the aggregation (or disaggregation) of spectrum into more valuable license configurations.").

300. The observation of overprotection and wasteful spectrum management dates back many decades. *See, e.g.*, ROGER G. NOLL, MERTON J. PECK, & JOHN J. MCGOWAN, ECONOMIC ASPECTS OF TELEVISION REGULATION 4 tbl.1-1 (1973) (explaining that in 1971, 37% of commercial broadcast spectrum assignments were unclaimed, and 66% of noncommercial assignments were unclaimed); ITHIEL DE SOLA POOL, TECHNOLOGIES OF FREEDOM 139 (1983) ("The present system makes for inefficient use of spectrum and thus causes its scarcity, whereas a market system achieves equilibrium by both reducing demand for and increasing supply of usable bandwidth.").

301. *See, e.g.*, Adam Santariano & Peter Burrows, *Apple, Verizon Took Years to Overcome Their iPhone Differences*, BLOOMBERG (Jan. 12, 2011), http://www.bloomberg.com/news/2011-01-12/apple-verizon-took-years-to-overcome-their-iphone-differences.html.

302. Rath, *supra* note 28, at 528.

other wireless licensees are subject to compromise by actions taken by rivals innocently, strategically, or maliciously.

That has not happened. "It is critical to our business that we are able to negotiate and resolve quickly most, if not all, rights and interference issues without seeking intervention or assistance of the Federal Communications Commission," writes Rath.[303] The regulatory quagmires seen in the Nextel-Public Safety dispute, or the decades-long misallocation of spectrum seen in the TV Band, do not materialize in the mobile markets. That is because the parties involved would not gain from such an outcome, and rationally take measures to avoid it. Rath continues:

> Wireless carriers' thousands of licenses and thousands of miles of adjacent and co-channel boundaries create a laboratory for evaluating whether this successful approach to interference "rights" negotiations is pertinent to a larger radio operating rights framework.
>
> Under current rules, licensees negotiate to extend rights into each others' licensed spectrum on a daily basis. These . . . involve hundreds of individual negotiations between companies' engineers who are tasked with the day-to-day operations of the network . . . . [C]arriers (including Verizon Wireless) do not always achieve their goals. That said, because the rights of both licensees are clear, there is no benefit to seeking regulatory redress. Instead, we manage the process in the market and look to other ways to gain the rights to spectrum we need to operate—typically through spectrum purchase or lease.[304]

This is the way "interference" disputes exist in liberal markets. They are simply a part of doing business, with remedies—including situations where one company will pay another to redirect a transmitter or move a base station—occurring not to eliminate conflicts but to economically manage them. CMRS licensees believe that "the rights of both licensees are clear," meaning that they are clear enough.[305] These approximate rules sufficiently resolve the interference problem when licensees have flexibility to switch network deployments or to trade rights, which typically happens after stalled negotiations are remediated "typically through spectrum purchase or lease."[306]

303. *Id.*
304. *Id.* at 529.
305. *Id.*
306. *Id.* at 530.

This experience is of enormous importance in informing policy makers as to how to most effectively deal with the interference problems in wireless. Phil Weiser and Dale Hatfield, however, take issue with this conclusion. They follow extant FCC commentary by arguing that the relatively harmonious nature of CMRS bands is due to the "stable and 'repeat players' "[307] that dwell there. There are several problems with this argument. First, this assumes the players to be exogenous; in fact, the liberal rules have allowed national networks to aggregate licenses and emerge as enterprises, holding spectrum rights portfolios quite distinct from what regulators initially licensed. Second, were the attribution correct that stable, repeat players are relatively successful in solving border disputes, the gains from this form of organization would again flow to the market forces that create such relationships. But third, the empirical claim has substance only in those instances where liberal spectrum rights have allowed the right kind of negotiations and adjustments by stable, repeat players. When the FCC has put different types of licenses into play—as in the Nextel-Public Safety 800 MHz band dispute, when fragmentation through interleaving of non-commercial, non-profit licensees froze the "interference" problem in place—the fact that there were stable, repeat players did not prevent gridlock.[308] Nor was gridlock prevented by the professionalism or intelligence of the engineers, many of whom work for cellular carriers that solve problems daily in negotiations with rival firms or are highly-trained experts dedicated to public service.[309]

Even more important is that the Nextel-Public Safety interference dispute was not remedied by the engineers, but by license trades. Greater specificity by incorporating rules into Nextel's SMR licenses or the police and fire departments emergency radio authorizations that would narrow

307. *Id.* at 529 (discussing Weiser & Hatfield, *supra* note 17, at 589).

308. Similarly, the interference problem in TV broadcasting has been handled in a hugely wasteful manner—setting aside the great majority of TV channels as taboo for at least six decades. Weiser & Hatfield, *supra* note 17, at 559. These taboos serve as guard bands, idle spectrum set aside to protect reception of adjacent signals. That station engineers might handle problems between them, fixing some residual conflicts, does not suggest that the stable, repeat game engaged for over sixty years by the TV stations has had any significant impact in reducing the social cost of interference control. That is because the narrowly specified transmission rights in TV broadcasting prohibit more productive activity, a problem that cooperating engineers cannot fix.

309. Indeed, the widely acknowledged waste of spectrum allocated to wireless deployments in the military occurs not due to the lack of knowledge or dedication of American soldiers or U.S. Defense Department employees, but due to the institutional basis on which the government agency makes its resource choices.

opportunities for spillovers[310] was not the answer. What would, in other instances, have been secondary market transactions were here executed in the FCC's "spectrum swap," a proposal first advanced by Nextel. That a regulatory proceeding lasting about a decade was required to fix the interference problem was due to the sharp preemption of markets by FCC spectrum allocation policy. Mobile markets, with liberal licenses held by responsible, profit-seeking agents, do not have to wait for regulatory interventions to defragment regulated uses. Not having to ask regulatory permission for a spectrum swap generates efficiencies, including stable, repeat players who behave rationally with respect to cost-benefit calculations.

F. THE COSTLY AND UNPRODUCTIVE SEARCH FOR ADDITIONAL SPECIFICITY

> [R]eform may most need to focus on the precise definition of rights to the spectrum. These rights were ill-defined almost 80 years ago and, despite the emergence of relatively efficient institutions for addressing spectrum use, remain in need of reform today. Finally, such reform must also recognize that, much as defining rights to land has not been simple, clarifying the rights to spectrum will be a complex task.[311]

This Article suggests that this conventional wisdom to "focus on precise definition" is misguided. Well-established reforms have produced de facto spectrum ownership rights that efficiently promote economizing in the provision of wireless markets, including large-scale investments in complementary wireless networks, devices, and applications. Such reforms are proven to scale extremely well, meaning that they can generate large new gains in economic welfare if extended and accommodate a diverse variety of technologies, business models, and economic structures, producing the price data key to rationally evaluating relevant tradeoffs in the allocation of radio spectrum.

Greater precision in usage rights can be helpful, but such improvements are not costless. To the extent that further clarifications are a complex task, they invoke the prospect of significant delays and rent seeking expense, not to mention anti-competitive outcomes when such technical specifications restrict innovation (a common regulatory approach to mitigating

310. *See* 800 MHz R&O, *supra* note 128; *see also* MURRAY, *supra* note 124 (discussing Nextel SMR as an example of unwinding and re-banding fragmented rights allocated by sequential regulation across private and public licensees).

311. Berresford & Leighton, *supra* note 250, at 37.

interference) or are steered to protect favored interests, restricting competition (a standard regulatory outcome).

Extremely large welfare increases are associated with the provision of additional bandwidth injected into the market via existing CMRS templates. This can be seen not only in the analysis offered in this Article, but in the conclusion of the FCC's 2010 National Broadband Plan: in emphasizing the prime importance of wireless services to the development of both broadband markets and the U.S. economy, it ignored the issue of rights clarification.[312]

Many scholars see things differently, reversing the order of operations, describing technical specificity by which efficiency occurs, over the outer boundaries of complementary rights bundles sought by capital-intensive network enterprises. Matheson & Morris outline a seven-dimension paradigm to define "electrospaces."[313] The approach builds on the "TAS" template put forward by De Vany et al. (1969), which defined Time, Area, and Spectrum in four dimensions (longitude and latitude being required for Area)[314] and which has been effectively implemented in the form of CMRS licenses. Matheson & Morris expand the format, as illustrated in Figure 5, *infra*, by specifying altitude, azimuth and elevation angle.[315]

The reason for this is that multiple wireless communications may take place at different altitudes, particularly when using fixed point-to-point links connecting with beam transmissions. The same basic idea allows

312. None of the seventeen high-level spectrum policy recommendations in the NBP propose greater delineation of border contours for licenses. They focus, rather, on moving 500 MHz of CMRS spectrum into the market by 2020. *See 2010 NBP*, *supra* note 3, at 10. This reveals an appropriate emphasis on bandwidth using definitions already available. It does not settle all remaining definitional questions, of course, and there are likely to be incremental changes that could improve the utility of spectrum use rights. For instance, streamlined dispute resolution processes have been previously suggested. *See Wireless Craze*, *supra* note 30, at 461–62. Some countries have experimented with new institutions to expeditiously resolve interference disputes. Charles Jackson describes New Zealand's system, which calls for binding arbitration before a tribunal composed of government officials to make judgments based on listed criteria. *See* Charles L. Jackson, *Spectrum Markets: Challenges Ahead*, Presentation at Northwestern University, Kellogg School of Management (June 2–3, 2011) (presentation slides available at http://www.kellogg.northwestern.edu/meds/spectrummarkets/slides/Jackson%20Thoughts%20on%20Spectrum%20Property%20Rights%20and%20Spot%20Markets.ppt). Guatemala's 1996 reform legislation mandates private mediation to resolve conflicts; if such a process fails, the telecoms regulator is then mandated to decide the issue. *See* Giancarlo Ibarguen, *Liberating the Radio Spectrum in Guatemala*, 27 TELECOM. POL'Y 543, 546 n.17 (2003).

313. MATHESON & MORRIS, *supra* note 56, at 7 (defining "electrospace" as an alternative term to include features of "frequency, time, space, direction, and other directions" in the electrospace dimensions of spectrum "location").

314. De Vany et al., *supra* note 38, at 1501.

315. MATHESON & MORRIS, *supra* note 56, at 9.

communications traffic to overlap in TAS cubes, for example, by directionality, altering the angle of signals across the horizon (azimuth), or by elevation.

Figure 5: Defining Electrospace Parcels as per Matheson-Morris (2011)[316]

QUANTITY	UNITS	# OF DIMENSIONS
Frequency	kHz, MHz, or GHz	1
Time	seconds, hours, years	1
Spatial Location	latitude, longitude, altitude	3
Direction of Travel	azimuth, elevation angle	2

Within coordinated radio networks, the technical possibilities are boundless.[317] Consider just the seemingly uncontroversial Time dimension: It is evident that there is no limit to the number of periods that can be defined as the relevant term for a given spectrum right. One can simply divide the Time unit by progressively higher integers. Yet the exercise instantly becomes irrelevant for public policy. The task in fashioning property rights is not to determine the smallest units that are possible to define, but to determine the size and shape of rights that can most efficiently be (a) defined by regulators, and (b) transferred into productive use. The latter process seeks to discover new and more useful ways of sharing the resource. The primary task in the "IPO-like release" of spectrum rights to the market is to package authorizations that assist, or at least do not hamper (as with crippling fragmentation), those productive activities by forcing costly transactions on the market to reassemble complementary rights.

As David Friedman posits:

316. Reproduced from MATHESON & MORRIS, *supra* note 56, at 8 tbl.1.

317. *Report of the Interference Protection Working Group, FCC Spectrum Policy Task Force*, Nov. 15, 2002, at 5, http://www.fcc.gov/sptf/files/IPWGFinalReport.doc [hereinafter *IPWG Final Report*], *cited in* Goodman, *supra* note 212, at 300 n.92 (quoting the Interference Protection Workshop remarks of Paul Steffes):

> Obviously, the number of users and the management of the problem becomes dramatically enhanced [as spectrum use becomes more complex. Consideration of interference is] at least a six dimensional problem, meaning spatial, x-y-z, frequency, time and waveform, and of course since the wave form can be infinitely complicated, you can make it an n-fold problem, which basically has more variables than you have numbers.

Id.

> When constructing bundles of rights the first question becomes "Which rights belong together?" If I own the right to farm the land, the right to walk on the land is worth more to me than to anyone else, so the two belong in the same bundle. . . . The right to forbid radio waves from passing over my property, on the other hand, is very little use to me. If every property owner had that right, setting up a radio station would require unanimous consent from every owner within range of the broadcast, making a transfer of the right from the owners to the person to whom it is of most value a prohibitively difficult transaction.[318]

The task of drawing boundaries around property rights is not to define all possible configurations but to provide a cost-effective means for resource optimization. In assigning spectrum rights to private actors who will then organize wireless services using them, the government need only define those parameters that it has a comparative advantage in designating. Clearly, a too parsimonious definition that does not establish sufficient authority for licensees to invest in creating networks, such as a TAS license that omitted the A, would fail to provide the legal inputs necessary for economic maximization. By the same token, a rights definition that over-specifies rights can fragment ownership so as to undermine efficiency. These policy errors give rise, respectively, to the twin tragedies of the commons and the anti-commons.

TAS holders are capable of designing sharing arrangements for directional signals and transmissions at different heights above surrounding terrain. Indeed, mobile networks already pack their CMRS license-defined spaces with intense traffic exploiting these dimensionalities, which is why Matheson and Morris, having observed market development of the capacity-increasing technologies that exploit such dimensionality, are aware of and keen to define them.[319] These strategies have already been created and productively deployed via the licenses in use.[320] Lacking economic gains from further specification by the state, there is no reason to shift organizational authority for partitioning such spaces back to regulators.

Indeed, the TAS rights proposed by De Vany et al. can be criticized for including Time. Matheson and Morris approve of and expand upon the inclusion of this variable in the contours that they recommend, commenting: "Time can be subdivided over a wide range of increments."[321] Yes, it can. It

318. DAVID D. FRIEDMAN, LAW'S ORDER: WHAT ECONOMICS HAS TO DO WITH LAW AND WHY IT MATTERS 113 (2000).

319. MATHESON & MORRIS, *supra* note 56, at 14.

320. *Id.* at 15.

321. *Id.* at 9.

can be so subdivided by legal authorities in issuing initial rights and by private rights holders who obtain such rights and then seek to optimize their use. The question at hand is not "What can be defined?" but "What need be defined by the state such that the optimization process can most effectively proceed from there?"

Because there is high complementarity between the productive use of a given frequency space from one minute to the next and from one decade to the next over networks of high fixed cost, infrastructure, and content agreements,[322] bundling rights over Time is the best method. As networks are planned, deployed, operated, and upgraded over long time horizons (measured in decades), continuity of spectrum rights proves efficient. Breaking frequency access rights into tiny nanoseconds[323] would impose needless transaction costs as firms would engage in market trading to reassemble what public policy has arbitrarily disaggregated. Indeed, re-auctioning license rights over a large time period of ten or twenty years would dissipate value by discouraging ongoing investments in the networks. Should licensees have to re-bid to retain license rights, the regulator would have to provide those licensees with incentives to curtail maintenance or upgrades several years prior to the re-auction date.

U.S. regulators have avoided this cost of variation on time to return investment by defining rights indefinitely. While wireless licenses have explicit terms (usually 10 years), they come with an explicit "expectation of renewal" in perpetuity.[324] Internationally, there has been some confusion on this issue. For instance, New Zealand began auctioning wireless licenses in 1989 and was to re-auction licenses after the 20-year license terms began expiring in 2010.[325] This approach, which would have induced carriers to

322. Online video over mobile broadband introduces new economies of scale to the mobile equation, carried over from traditional media business models. *See generally* JEFF ULIN, THE BUSINESS OF MEDIA DISTRIBUTION: MONETIZING FILM, TV AND VIDEO CONTENT IN AN ONLINE WORLD (2010).

323. As has been suggested in Eli Noam, *Spectrum Auctions: Yesterday's Heresy, Today's Orthodoxy, Tomorrow's Anachronism. Taking the Next Step to Open Spectrum Access*, 41 J.L. & ECON. 765, 779 (1998) (on access codes at real-time demand).

324. The FCC has addressed consistent "renewal expectancy" across commercial mobile broadband licenses. In the Matter of Amendment of Parts 1, 22, 24, 27, 74, 80, 90, 95, and 101 To Establish Uniform License Renewal, Discontinuance of Operation, and Geographic Partitioning and Spectrum Disaggregation Rules and Policies for Certain Wireless Radio Services, Notice of Proposed Rulemaking and Order, 25 FCC Rcd. 6996 (2010), *available at* http://apps.fcc.gov/ecfs/document/view?id=7020520540.

325. New Zealand Ministry of Economic Development, Radio Spectrum Management, *The Reallocation of Commercial Spectrum Rights at Expiry, Background Information*, http://www.rsm.govt.nz/cms/policy-and-planning/projects/recently-completed-work/rights-at-expiry/background-information [hereinafter *Reallocation of Commercial Spectrum Rights*];

inefficiently depreciate their capital, was circumvented with new rules promulgated between 2003 and 2005.[326] The regulator assessed renewal fees instead.[327] All three existing wireless networks retained their spectrum licenses and stayed in business without an auction.[328]

The outcome is presumptively efficient. Had these incumbent firms not been value-maximizing rights holders, they would have previously sold to higher bidders. Moreover, the spectrum rights developed for the market in one period complement the supply of similar services offered in the next. In shifting ownership back to the state (as auctioneer) at specified intervals, re-auctions disrupt this complementarity. While other property rights, such as those for intellectual property, are properly time-limited insofar as the creative efforts being protected have already occurred, the productive use of spectrum relies on *continuing* licensee investments in networks and applications that exclusive rights encourage.[329]

Of course, where transaction costs are assumed to be zero, such considerations are irrelevant. Rights are reassembled easily, flawlessly, and instantly. But, the exercise of rights definition can only have meaning under the assumption of costly transactions. The basic strategy is to bundle packages of rights such that transactions, following rights assignments, are economized. That does not imply that rights should, going forward, be restricted. At the point where contracting parties internalize transaction costs, economic incentives police the partitioning. Indeed, with flexible-use rules in place, rights holders reveal efficiencies by adjusting to changing demands and opportunities.

Observation of wireless markets yields insights that inform efficient rights definition. Licensees deeply and finely divide rights to use radio spectrum. Very large quantities of voice minutes (to MVNOs) or data traffic (to M2M aggregators) are traded.[330] Tiny increments of time for single voice

Spectrum Auctions, http://www.rsm.govt.nz/cms/licensees/spectrum-auctions (citing New Zealand Radiocommunications Act of 1989, Pub. Act 1989 No. 148, http://www.legislation.govt.nz/act/public/1989/0148/latest/DLM195576.html).

326. *See Reallocation of Commercial Spectrum Rights*, *supra* note 325. These include policy changes in May 10, 2003, for effect in 2005, to determine price-setting formulae. *Id.*

327. *See Reallocation of Commercial Spectrum Rights*, *supra* note 325.

328. Simon Davies, *New Zealand Networks Renew Radio Spectrum Licenses*, CELLULAR NEWS (Mar. 29, 2012), http://www.cellular-news.com/story/53714.php.

329. This confusion about time limiting spectrum rights, analogous to patents, is found in WILLIAM J. BAUMOL & DOROTHY ROBYN, TOWARD AN EVOLUTIONARY REGIME FOR SPECTRUM GOVERNANCE: LICENSING OR UNRESTRICTED ENTRY? (2006) (suggesting spectrum license term limits akin to patent term limits).

330. Fifteenth Annual Competition Report, *supra* note 20, at 9672 (with an increase in wholesale subscribers in 2009).

calls or text messages are also offered, although minimum bundles (for example, thirty minutes for a low-cost, pre-paid phone card) are routine, and price-per-unit falls dramatically as larger volumes are purchased.[331] Naked spectrum deals are also routine, but only in transactions where spectrum inputs are acquired by networks.[332]

Having aggregated bandwidth through license purchases, mobile carriers then bundle spectrum access with network access. The aggregation of licenses, as well as the bundling of service with spectrum, serves to eliminate "interference" by eliminating borders. There is no evidence that markets would prefer to organize spectrum sharing by dividing parcels with respect to time or directionality of signals. The TAS format developed even prior to the advent of CMRS licenses appears to work well—so well, in fact, that the "T" can be deleted;[333] just Area and Spectrum need be specified. Basic border spillover rules, including the maximum radiation received at the edges of the contour, are in place for CMRS[334] and can reasonably be used for allocations in the future.

The Matheson and Morris approach is, in our view, properly motivated:

> We present a way to express the rights to use spectrum that is not tied to any specific service or technology. It would allow market forces to allocate spectrum such that new radio technologies and applications can be rapidly accommodated with minimal regulatory oversight.[335]

The construction focuses single-mindedly on the wrong margins, however:

> [T]he physics of radio signal propagation that underlie any spectrum applications and introduces the seven-dimension "electrospace" approach to describing radio signals and the rights

331. *Id.* at 9677 (where price-per-text has dropped 25% for the fifth consecutive year, according to an analyst estimate).

332. *Id.* at 9716 ¶ 62.

333. Regarding the TAS bundle, see De Vany et al., *supra* note 38, at 1517–18. See Section III.F, *supra*, for a discussion on time as a resource appropriately included in an exclusive use bundle managed by a private agent. The time dimension relates to the capacity utilization choice of the agent. Peak and non-peak usage patterns of spectrum is a dynamic feature of wireless service, along with various fixed and variable costs calculated by spectrum licensee.

334. CMRS operates under Part 22 and Part 90, with borders that share with public safety, with "analog AMPS and four different digital technologies, TDMA, CDMA, GSM, and iDEN." *See IPWG Final Report*, *supra* note 317, at 4.

335. MATHESON & MORRIS, *supra* note 56, at 5.

> to emit them. We argue that increased exploitation of these dimensions will be central in improving spectrum capacity.[336]

It is absolutely beneficial to more intensively and productively use the dimensions the authors define, and even dimensions too complicated for the authors to define[337]—but it is not the case that regulators should be charged with defining these dimensions.[338] Indeed, charging the administrative process with too much precision has reliably led to non-market failure.[339] The costs generated by complex tasks will tend not to deter public sector agents who arguably prefer problems that generate administrative process and delay

---

336. *Id.*

337. This is their approach to polarization and modulation, which could open new definitional boundaries: "The high degree of necessary cooperation between users of different polarities and modulations suggest that establishing regulatory boundaries between access rights across those dimensions would not be particularly useful, at least with current technology." MATHESON & MORRIS, *supra* note 56, at 9. Of course, with more advanced technology, liberal license holders would be free to carve out their own new subdivisions, and—were such partitioning to yield new efficiencies—would have incentives to discover and deploy such advances. The analysis is precisely grounded, and its implications are relevant not only to what MATHESON & MORRIS exclude from their definitions, but much of what they include.

338. The Interference Protection Working Group for the FCC Spectrum Policy Task Force Report critiqued interference definitions as technical and idiosyncratic:

> Finally, inconsistencies may appear to exist where the FCC's rules contain different expressions of engineering units that have been derived from different considerations of power, relative power, or electric field. These differences reflect the different approaches to describing and characterizing interference and its impact that are peculiar to the specific situation such as for broadcast or mobile services, for example, D/U and C/I, or dBm and dBmV/m.

IPWG Final Report, *supra* note 317, at 31.

339. *Id.* "The same variability in language on interference that pervades the FCC's rulemaking proceedings and the resulting rules also gives rise to inconsistent discussion of the impact of interference from a non-technical perspective." *Id.* The critique focuses on the consistency and standardization of language. Although "clarity" is a requested trait for form, the object is communicative and negotiable simplicity rather than technical finesse. *Id.* at 33. It separates "distinctions between of levels of interference" from information-cost aspects of simple rights definition, for "consistent and appropriate" applicability to "remove some ambiguity" for enforcement. *Id.* "Clarity" is applied to the communicative aspect of rulemaking.

> [A]ctual interference rules themselves are not easily identified and isolated in the context of all the rules governing a particular service. For example, for certain services interference may be indirectly governed by specifying minimum separation distances or limitations on transmitter power and antenna height—without ever mentioning the word "interference" or referring to levels of interference.

Id.

controversial, albeit more fiercely competitive, outcomes. Profit-seeking entrepreneurs, however, aggressively search for promising opportunities to open up new lines of commerce, as are facilitated by exploiting additional dimensionality in the supply of services, either directly through vertical integration or via sales to customers.

One clear driver of this attempt to draw such precise rights in law is provided by the idea that cognitive radio, or other devices adept at opportunistically deploying radio spectrum, needs tiny slices of bandwidth to be defined for its use. Dynamic access is the explicit concern of many such definitional exercises.[340] But the use of such slivers does not require that regulatory definition. Contracts that provide for dynamic access to licensed spectrum are quite capable of providing such inputs, as observed in the market. Intense use is made of "white spaces" with devices that seek under-utilized frequency spaces, both in the subscriber devices purchased through carriers (or their partner firms), and via virtual networks accessing spectrum via wholesale market transactions.[341] The organizational patterns of such services, however, often conflict with the use models assumed by analysts, which typically behave more like spot markets than long-term relationships. As noted, the observed business models rely on bundled access (spectrum plus network services) and are marketed in ways that appear distinct from those used in, say, unlicensed spectrum.[342] This is asserted to be a bug by advocates of unbundled access models. It is, in fact, a feature. The parties to the observed contracts internalize costs and benefits, including organizational costs and marketing or billing expenses, and so tailor deals that incorporate such factors. Alternative options are available, but rejected in favor of models considered more valuable by the parties directly involved.

In fact, the fragmented "commoditization" of spectrum rights is not a categorically superior form of market organization. How a resource is packaged and traded depends on various cost and demand factors specific to that market.[343] In spectrum, it is quite clear that substantial costs accompany

340. *See, e.g.*, Timothy Forde & Linda Doyle, Towards a Fluid Spectrum Market for Exclusive Usage Rights, 2nd IEEE International Symposium on New Frontiers in Dynamic Spectrum Access Networks 620 (2007), *available at* http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=4221548; DE VRIES & SIEH, *supra* note 57.

341. *See* discussion *supra* Section IV.E (discussing mobile operators as spectrum owners and neighbors, with reference to Rath, *supra* note 28, at 529).

342. Rath, *supra* note 28, at 529.

343. Forde & Doyle explain that:

> The key characteristic of the clock auction is the relative simplicity of the price discovery phase, i.e. the clock phase. Firstly, its simplicity means that the burden on both the bidders and the auctioneer is low. The bidder

disaggregation, particularly with respect to defining and policing boundary lines. This is the central problem tackled in regulatory proceedings focused on determining interference rules, and yet the fact that the most commonly adopted and effective remedy is to eliminate such fragmentation seems to elude many policy makers and analysts.

However, there is one very promising avenue of inquiry that properly targets mechanisms for assigning rights in a dynamic access environment. Tim Forde and Linda Doyle deal explicitly with the cost of borders, and note that it will tend to become more severe as digital wireless technologies advance; this reasoning represents a needed correction to the conventional wisdom that such systems are categorically making spectrum sharing easier:

> In an increasingly fragmented and less-regulated spectrum landscape, there will be an inevitable chafing of rights at the boundaries between the users of neighbouring blocks of spectrum; the spectral activities of one network may impinge on the ability of a neighbouring network to extract maximum value from its exclusively assigned spectrum.
>
> Nonetheless, it is argued that it is possible to reduce, or eliminate, the existence of such externalities through the adjustment and exchange of rights through value extraction-focused bargaining. In essence, this represents a shift from a mindset of unilaterally enforcing rights to one of mutual remediation of any encroachment. Such an approach may . . . [allow] neighbours to find a tolerable level (a balance) of interference.[344]

Forde and Doyle then present a proposal for how exclusive spectrum rights could be auctioned such that complementary rights—which, in particular, exhibit spillover effects between them—can be discovered and assembled into bundles. This will "address a variety of coexistence issues."[345]

G. THE AM RADIO CRITIQUE

Radio engineering expert Charles Jackson, while agreeing that exclusive spectrum rights work well for services such as mobile telephony (cellular and

---

> simply has to sum the cost of any items it wants to package, ascertain that they are within its budget for that resource and make its bid.

Forde & Doyle, *supra* note 41, at 331.

344. Timothy K. Forde & Linda E. Doyle, *Exclusivity, Externalities & Easements: Dynamic Spectrum Access and Coasean Bargaining*, Proceedings of the IEEE International Symposium on New Frontiers in Dynamic Spectrum Access Networks, Dublin, Ireland, at 303–15 (Apr. 2007), http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=04221510.

345. *Id.*

PCS), suggests that they work poorly for certain other technologies.[346] In particular, he argues that AM radio, the initial mass-market service that drove policy makers to assemble a spectrum regulatory agency, is problematic. AM radio, a one-way broadcasting service, operates at low frequencies that are not well behaved over geographic distances.[347] In particular, they tend to unexpectedly blanket larger areas than they are designed to serve, destroying rival communications beyond their markets. These problems, in Jackson's view, are responsible for the creation of administrative allocation of radio spectrum.[348]

Jackson is correct that the federal government was involved, from the earliest days of AM radio, in coordinating broadcasting rights. The U.S. Department of Commerce—under the Radio Act of 1912, but with limited authority to assign wireless rights for the purpose of "minimizing interference"[349]—employed what Senator C.C. Dill called the common law "right of user" rule to define and enforce rights.[350] This regime did not give scope to advance "public interest, convenience or necessity," which is why policymakers and incumbent commercial broadcasters favored new legislation.[351] Common law rules limited regulatory discretion and, pointedly, would predictably allow for competitive entry. "Public interest" licensing erected barriers that protected incumbents. Absent such common law underpinnings, the legislation itself remains a mystery.[352]

---

346. Charles Jackson, Limits to Decentralization: the Example of AM Radio Broadcasting Or Was A Common Law Solution to Chaos in the Radio Waves Reasonable in 1927?, at 30, Telecommunications Policy Research Conference (2005) (copy on file with authors).

347. *Id.* at 24.

348. *Id.* at 31.

349. 62 P.L. 264; Radio Act of 1912, Pub. L. No. 264, 37 Stat. 302; *see also* MARVIN R. BENSMAN, THE BEGINNING OF BROADCAST REGULATION IN THE TWENTIETH CENTURY 8–9, 34 (Jefferson, North Carolina: McFarland 2000) (describing the general powers in the Department of Commerce to "follow closely scientific discovery and invention in the principles, methods and instruments of radio communication, all of which are subject to rapid change.").

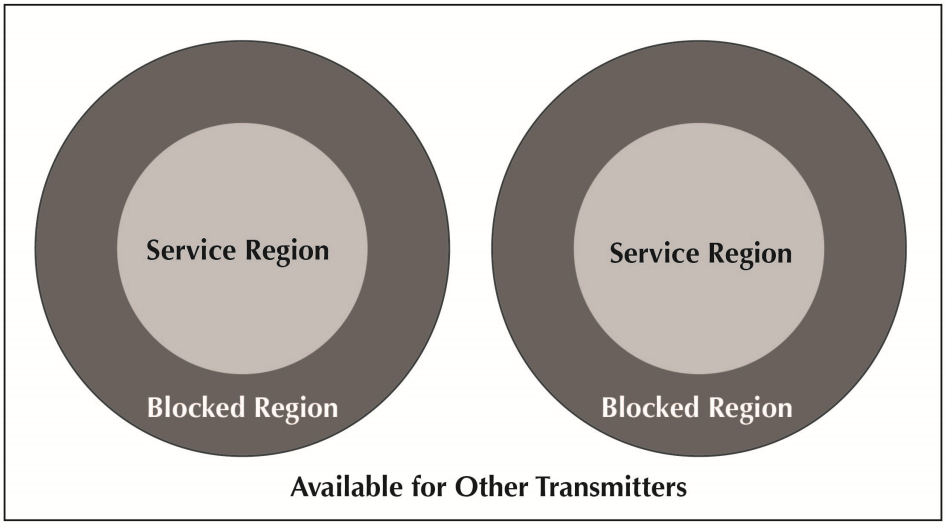
350. CLARENCE C. DILL, RADIO LAW, PRACTICE AND PROCEDURE 77–78 (Washington, D.C.: National Law Book Company 1938) (citation omitted).

351. *Id.* ("The most important of these which the radio statute [Radio Act of 1927] sets aside is the principle of acquiring a certain property right by user . . . . Congress wrote into the radio law the provision that user should have no effect upon the right of the Commission to provide for the use of any wave length by a new and different person if the public interest would be served thereby."); *see Wireless Craze*, *supra* note 30, at 360–73.

352. The traditional explanation of the 1927 Act, repeated in Jackson's paper, is that the Secretary of Commerce had no authority to further enforce broadcasting rules as per the 1926 *Zenith* opinion issued by a federal district court. This is wrong. A 1923 federal district court ruling, in *Intercity*, held that the Commerce Department *did* have the authority to issue

Jackson argues that when wireless contours are clear and easy, private ownership makes sense. When rights are more complex, they are difficult to define, and poor candidates for private ownership. He offers, as an example of the first case, the situation in Figure 6. There, on a given frequency, geographic separation between two broadcast stations yields opportunities for other transmissions. Since the emissions of the two stations do not overlap, a party desiring to use the "white space" (free of interference) would easily be able to obtain the relevant rights, presumably via initial (regulatory) assignment or through negotiation with a spectrum owner.

Figure 6: Easy Spectrum Contours for Broadcasters[353]

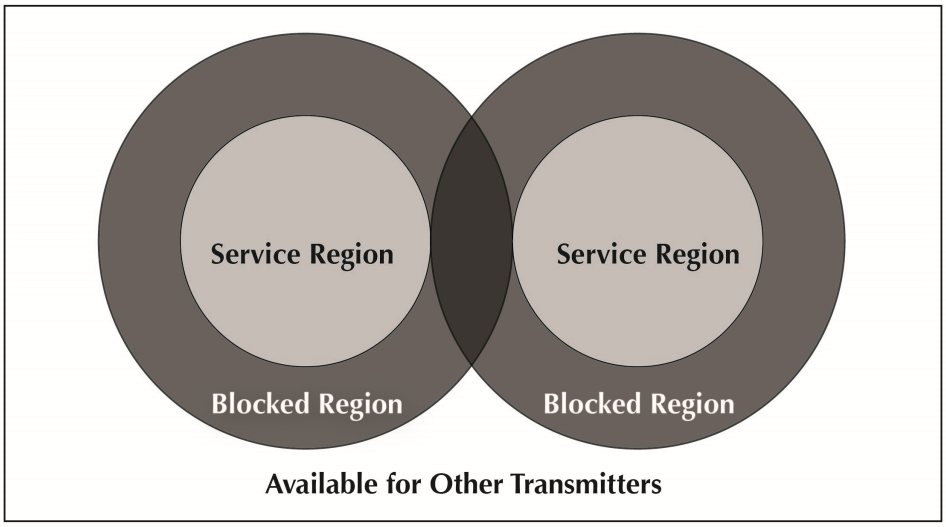


However, this happy equilibrium is said to collapse when the picture changes to reflect the complexities of AM broadcasting. Then service contours overlap, as in Figure 7:

licenses so as to restrict conflicts. It was the political choice of Commerce Secretary Herbert Hoover—curiously rejecting the verdict yielding his agency more power—that led to the "period of the breakdown of the law." To remedy this, all a statute need do was clarify that the earlier opinion (*Intercity*) had been correct and that the Government's power to enforce rules to "minimize interference" were intact. The legislation that resulted rejected this limited enforcement patch, creating a wholly new regulatory structure. As explained by the participants, including Hoover and Senator Dill, the goal was not to restore interference rules but to extend political control over spectrum. Major commercial broadcasters were themselves in favor of this shift in property rights, as they realized rents from enhanced barriers to entry. This is explained in much greater detail in my articles, Thomas, W. Hazlett, *Rationality of Regulation*; *Physical Scarcity, Rent Seeking and the First Amendment*, 97 COLUM. L. REV. 905 (1997), and *Wireless Craze*, *supra* note 30.

353. Figure 6 reproduced from Jackson, *supra* note 346, at 14 fig.2.

Figure 7: Not So Easy Spectrum Contours for Broadcasters[354]



Jackson argues that in the region where the interference of the two broadcasters overlaps, a difficult contracting problem results. Not one, but two parties must agree in order for an entrant to gain the right to reuse the spectrum space. In his words, "this splitting of property rights is . . . maybe not fatal, but certainly debilitating."[355] Jackson suggests that administrative allocation is therefore superior to private property in this situation.[356]

Jackson's analysis is lacking in this regard. Coordinating the two activities is a challenge that exists for state agents as well as for private resource owners.[357] Stochastic changes add to complexity, but do not change the calculus of the institutional choices for rights definition. The history of the FCC shows that administrative allocation is generally an expensive form of dispute resolution.[358] Typically, administrative allocation unduly constrains wireless applications, an overly conservative approach that lowers social welfare. Indeed, radio and television stations have been routinely under-allocated, lowering consumer welfare.[359] The results are general.[360] In UHF

354. Figure 7 reproduced from *id.* at 14 fig.3.

355. Jackson, *supra* note 346, at 14.

356. *Id.*

357. We here ignore the availability of standard contracting strategies that would remedy hold-out problems, including contingent contracts (payments to one station are made if and only if the other party agrees to the same terms) and/or the use of rival bids across multiple spectrum spaces, inducing a reverse auction.

358. *See* discussion *supra* Section I.A; NBP 2010, *supra* note 3 (citing the six- to ten-year reallocation process).

359. Thomas W. Hazlett & Bruno Viani, *Legislators v. Regulators: The Case of Low Power FM Radio*, 7 BUS. & POLITICS 1, 9 (2005).

TV, there are five taboo (unused) channels for each allocated channel per market;[361] in FM radio, three taboo channels are set aside.[362] This has proven highly wasteful.[363] It is precisely the sort of interference control that one would associate with administrative allocation—it reduces total output but the result looks harmonious, as the most visible conflicts are reduced. The wasteful outcome differs with private spectrum ownership rights, however, as the licensees—when permitted to use spectrum for whatever they determine is its highest and best use—would increase profits by controlling interference in a lower cost manner than regulation. And the issue is not whether private rights holders will do this imperfectly, but whether they can outrun the bear—the state property alternative.

In asking whether administrative allocation or private rights holders provide the best means to use spectrum, Jackson's example is better than he imagines. In positing two independently owned stations with overlapping (deterministically or stochastically) emission contours, he addresses rights definition as the FCC often does. The agency creates fragmentary spectrum use rights, and disperses them, even while they are highly complementary.[364] That makes the creation of efficient wireless operations that require a high degree of coordination needlessly difficult. The FCC then attempts to supply its own form of coordination by further "command and control" allocation measures, on the grounds that market failure occurs due to high transaction costs.

In fact, the "debilitating" problem would be avoided by an efficient assignment of legal rights: joint ownership of the frequency space within the box. Placing both station contours within one ownership bundle does not magically eliminate radio interference, but does reliably resolve the proffered

360. Hazlett et al., *Optimal Abolition*, *supra* note 250, at 103–04.

361. REPORT OF THE SPECTRUM EFFICIENCY WORKING GROUP 24 (2002) (citing S. Merrill Weiss, Address at the Public Workshop on Spectrum Efficiency (Aug. 5, 2002)), *available at* http://transition.fcc.gov/sptf/files/SEWGFinalReport_1.pdf; Michael Marcus, *Comments re: Ex Parte Comments of Sports Technology Alliance*, ET Docket No. 04-186, at 2 (May 5, 2008), *available at* http://fjallfoss.fcc.gov/ecfs2/document/view.action?id=6520008054.

362. Hazlett & Viani, *supra* note 359, at 4–5.

363. Dale N. Hatfield, *The Challenge of Increasing Broadband Capacity*, 63 FED. COMM. L.J. 43, 57 (2010) ("The lack of perfect transmitters and receivers inevitably results in the loss of some capacity between bands due to the need to, for example, provide a buffer or guard band between the two bands to supply the necessary isolation and thereby reduce the associated interference to an acceptable level. Excessively fragmenting the spectrum among different bands reduces the overall technical efficiency of spectrum utilization for this reason.").

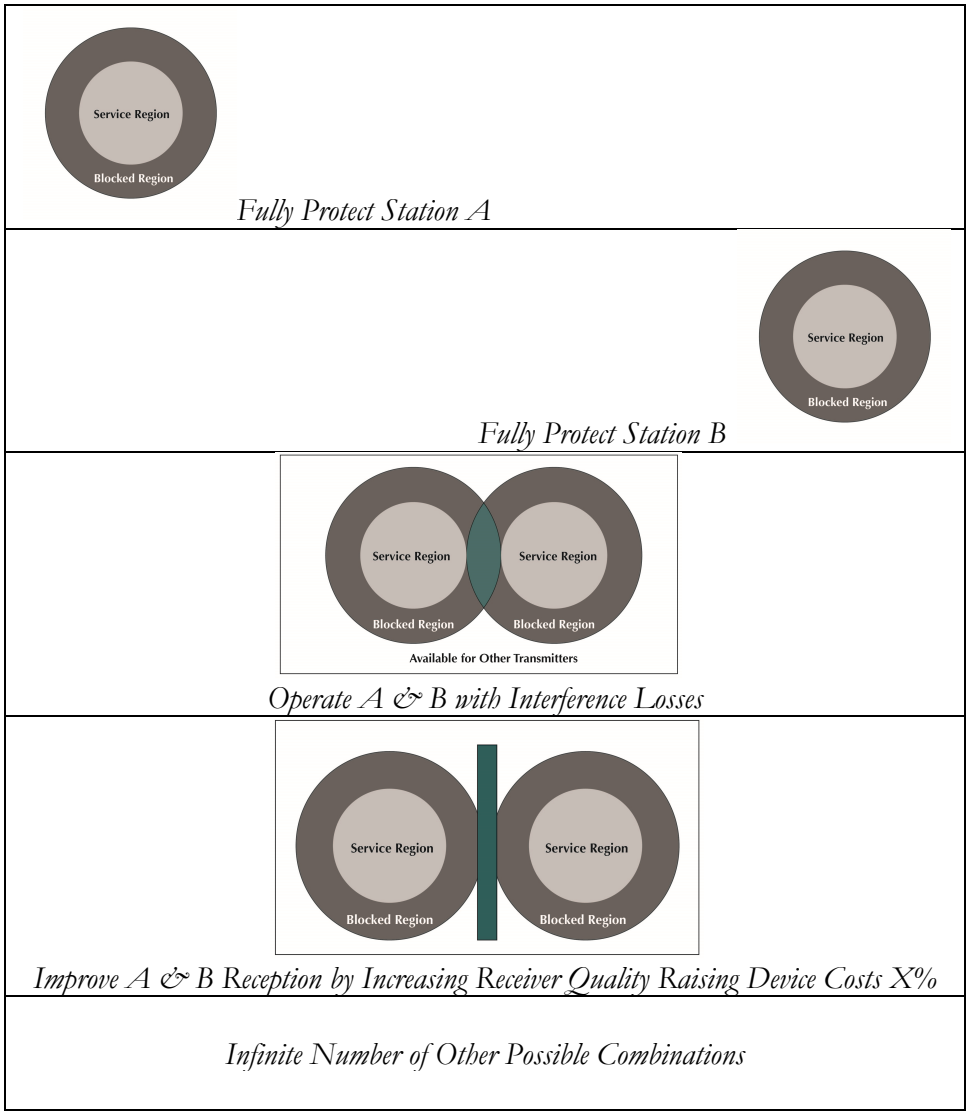
364. *See* Porter at al., *supra* note 144 (discussing the efficiencies of combinatorial auctions).

disputes. Spectrum sharing is optimized because marginal costs and marginal benefits flow to the (integrated) rights holder. This ownership pattern would naturally emerge in the absence of the transaction costs imposed by inefficient rights distributions, as both licenses are together worth more due to the coordination costs that Jackson wrongly associates with market failure.[365]

Forde and Doyle explicitly feature such rights aggregation as a central aim of an efficient regulatory system. The model they develop would allow markets to avoid the "externality" problems that Jackson considers. They note that there are many ways that rival radio stations could peacefully co-exist: investing in better transmitters or receivers; moving or repositioning certain equipment; splitting time; altering power levels.[366] But a general fallback will be that "certain frequencies will end up being sold in combinations . . . and never in individual blocks."[367] With integrated control, managers will seek to maximize the value of both broadcasting opportunities jointly, a path that will logically lead to the most efficient resolution of the interference spillover.[368] The importance of integrated ownership is that the profit-seeking licensee will search for the compromise yielding the highest output, and implement that solution without being deterred by the need to transact with other rights-holders.

365. Jackson, *supra* note 346, at 14.
366. Forde & Doyle, *supra* note 41, at 331.
367. Forde & Doyle, *supra* note 340, at 628.
368. *See infra* Figure 8.

Figure 8: Options When Interfering Stations Are Under Integrated Ownership



H. LIABILITY RULES VERSUS PROPERTY RULES

Pierre de Vries and Kaleb Sieh also argue for "unambiguous" determination of spectrum use rights, largely ignoring the costs of this regulatory enterprise and underestimating (or ignoring) the degree of utility of existing liberal license templates assigned to responsible economic agents.[369] This is a key omission, particularly as they take up the question as

369. DE VRIES & SIEH, *supra* note 57.

to whether it is best to use property rules or liability rules in defining spectrum uses. They conclude that, because the literature is undecided on which set of rules is optimal, it is best to be agnostic on this question.[370] This is a seriously flawed conclusion.

There are many dimensions in which to see property ownership as a useful social institution.[371] One is that owners take care to conserve, nurture, and grow their resources, taking appropriate care—whenever it is worth the cost—to protect or improve it.[372] Exclusive control, as afforded by property ownership, does not mean that resources are reserved for "exclusive use," but that the owners will attempt to maximize their value, using them to do whatever yields the highest return. A frequency space worth $1 million as an input into a particular wireless service is not, alternatively, used to provide $10,000 worth of value as a guard band to a technically lagging neighbor.

Liability rules are substitutes for property rules when the latter are prohibitively expensive to use. The standard case regards auto collisions. Were transaction costs zero, people who might be involved in traffic accidents could contract, agreeing to terms regarding payments (perhaps specified by an arbitration service) following any damage-inflicting incident. Yet, transaction costs are not zero in the real world. In fact, the costs of contracting with all potential parties to a traffic accident are prohibitive.

Hence, a second best solution is called for. That is where liability rules come in. If Party A drives recklessly, causing an accident and destroying the automobile of Party B, we are already beyond property rules. Under the ownership system, A could have taken (or destroyed) B's auto, but only by paying a price acceptable to B to buy the car. Because the accident has occurred, and because A and B have not contracted over the price of the car, the damages must now be set by law. This is not a perfect system, as the value of the car to B must be calculated by the court (instead of established in a mutually beneficial trade), but it does lead to the best possible outcome under the circumstances.

For voluntary transactions where bargaining can occur, however, liability rules are socially useful. The process ensures that resources are used in their

370. *Id.*

371. For a general overview of the law & economics literature on property rights, see RICHARD A. POSNER, ECONOMIC ANALYSIS OF LAW 218–19 (New York: Aspen 8th ed. 2011); *see also* PROPERTY RIGHTS: COOPERATION, CONFLICT, AND LAW 282, 287 (Terry L. Anderson & Fred S. McChesney eds., Princeton University Press 2003). For the role of technology in resource use, see generally THE TECHNOLOGY OF PROPERTY RIGHTS (Terry L. Anderson & Peter J. Hill, eds., 2001).

372. *See* sources cited *supra* note 371.

highest valued employments. That is precisely what we should aim to achieve in radio spectrum usage, where the information known to regulators is sparse, and where incentives to discover or implement optimal employments is relatively weak. Liability rules vest regulators or courts to make valuation choices, and so continue the administrative allocation process, albeit perhaps in a different format. Indeed, some FCC allocations do apply liability rules—in particular, unlicensed "Part 15" regulations that authorize certain low power radio devices to operate, but under the condition that they accept all interference from other devices (whose users are relieved of liability) and to refrain from interfering with any licensed service (imposing full liability on the unlicensed device user).[373] This approach is used because of the non-exclusive spectrum rights associated with unlicensed operation; property rules are not an option here. But, having assigned exclusive rights to a liberal licensee, the process by which the rights holder bargains with others is extremely useful, revealing what other opportunities are available and how they stack up against the costs they impose. To allow others to use these spectrum spaces without authorization, forcing the rights holder to pursue liability ex post, not only imposes costly litigation but puts the determination of valuation back in the public sector. This surrenders the optimizing properties gained in the assignment of liberal rights, and turns choices between alternatives back into a legal-administrative question.

Hence, the following agnostic conclusion rendered by De Vries and Sieh is incorrect:

> There is an extensive literature on whether liability or property remedies are preferable. The various conclusions depend in no small part on the assumptions made in each case and there seems to be no consensus. Some regard liability remedies as the most suitable in externality cases, though different assumptions can lead to the conclusion that injunctive relief [won under property rules] is no worse, and may be better, than damages.
>
> More work is therefore needed before making recommendations on whether damages or injunctions are the preferable remedy in radio regulation . . . .[374]

Indeed, conclusions change with assumptions on when liability or property rules are most appropriate. Summarizing the classic contribution in the field, an essay by Guido Calabresi and Douglas Melamed published in 1972, Keith Hylton writes: "Property rules are generally preferable . . . . Liability rules are

373. *See* 47 C.F.R. pt. 15 (2011).

374. DE VRIES & SIEH, *supra* note 57, at 8.

used instead of property rules largely because high transaction costs make it infeasible to have property rules . . . ."[375] So the differentiation, rather than rendering a choice impossible, facilitates straightforward application to the issue at hand. The conditions prevailing in wireless markets demonstrate that bandwidth stewards are extremely important in coordinating efficient economic activity. Moreover, transactions between networks, suppliers, and customers provide robust market outcomes. Thousands of licenses have traded; scores of virtual networks have formed; hundreds of carrier-to-carrier roaming agreements have been executed; millions of customers have subscribed. All of these contracts have transferred spectrum rights on the property model *without* using liability rules.

I. OPTIMAL SPECTRUM RIGHTS DEFINED

The goals in defining exclusive spectrum rights were presented by De Vany et al in 1969 and have yet to change, despite gains in information transmitting capacity of radio transmitters and receivers.

> Ideally, the boundaries and field-strength limits of the initial TAS packages would be economically optimal—that is, they would be perfectly suited (in each dimension) to the use that would result from existing market and technological conditions. Initial optimality would save subsequent exchange costs that otherwise would be incurred in restructuring rights into optimal configurations. However, the information required for achieving initial optimality is not now available; obtaining the information could cost more than the resulting increment in value, and in any case this cost is likely to exceed the cost of achieving optimality through an initial round of exchanges. Some skillful guesses on original packaging should therefore be made, leaving the correction of mistakes to subsequent rights exchanges in the marketplace. In addition, even if initially optimal TAS packages could be defined, they would not remain optimal over time.[376]

This remains an excellent guide to policy. Hence defining contours can be made simple by reference to the CMRS rules already in place in the United States, currently a leading template for the use of spectrum integrated with mobile handsets and mobile services of broadband connectivity. Other regulators have their own templates that may also prove useful. Australia, for

375. Keith N. Hylton, *Calabresi's Influence on Law and Economics*, *in* PIONEERS IN LAW AND ECONOMICS 224, 230 (Lloyd R. Cohen & Joshua D. Wright, eds. 2009) (summarizing Guido Calabresi & A. Douglas Melamed, *Property Rules, Liability Rules, and Inalienability: One View of the Cathedral*, 85 HARV. L. REV. 1089 (1972)).

376. De Vany et al., *supra* note 38, at 1517.

example, defines "spectrum cubes" that have flexible use and can be easily aggregated in initial assignments.[377]

As noted in Section IV.F, *supra*, the TAS packages offered by De Vany et al. are probably over-defined; time is superfluous. The rights to use radio spectrum are efficiently defined as *perpetual* in duration.[378] The remaining dimensions, area and frequency, are obviously needed, however. The question that then arises relates to the definition of de minimus interference. Given that radio signals attenuate over geographic distance and frequency space, some detectable radio emissions will naturally leak into various other parcels. CMRS rules define these levels. There are small variations from country to country. Charles Jackson notes that the United States maintains a "flexibly enforced" boundary limit of -47 dBW.[379] New Zealand maintains a slightly quieter standard: -52 dBW.[380] In practice, they are probably indistinguishable aside from major step functions in available technology limits. Additional specification is likely superfluous, although disputes will inevitably arise. What can be added to the process is, as Jackson notes, a binding arbitration system—deployed by New Zealand—that can expeditiously resolve such conflicts.[381]

J. AUCTIONS AS INTERFERENCE CONTROL MECHANISMS

Rights assignments are central to the control of harmful interference. This seems counterintuitive to those familiar with the standard bifurcation of wireless policy: spectrum allocation establishes use rights; license awards then distribute those use rights.[382] In this scenario, rules limiting conflicts are the sole purview of the allocation process. License awards, whether by beauty contest, lottery, or auction,[383] simply transfer those rights among potential claimants.

In fact, the manner in which such transfers occur is key in determining harmful interference. It does overstate the matter to make the bold claim that most—indeed, an *overwhelming majority*—of radio interference disputes are

377. Hazlett, *Wireless License Values*, *supra* note 72, at 577 tbl.4 (describing "Spectrum Trading Units" of Australia where the regulator identifies blocks of such units).

378. All rights can be taken in a condemnation by the state, which involves the payment of just compensation. That would presumably apply with radio spectrum rights.

379. Jackson, *supra* note 312, at 10.

380. *Id.*

381. *Id.* at 14.

382. *See, e.g.*, John O. Robinson, *Spectrum Management Policy in the United States: An Historical Account* (FCC, Office of Plans & Policies, Working Paper No. 15, Apr. 1985).

383. Or, for that matter, via unlicensed use rights, where devices are licensed by the regulator.

resolved not by formal regulations or market-based spectrum contracts, but by merger. By integrating usage rights, firms internalize conflicts and deploy value-maximizing spectrum sharing rules in the natural matter of their network management. Nationwide mobile networks aggregate use rights across time, geography, and spectrum, and regulators "re-band" allocations to replace "interleaving" with contiguous blocks (as in the Nextel-public safety "spectrum swap").[384] Technical specificity often causes such border conflicts. Eliminating such borders via integration makes them disappear.

The merger remedy is not costless. Management expense typically mounts with scale and complexity; license aggregation tends to produce costs that at least partly offset the gains from creating a more efficient organization of integration. Institutions to accommodate this balancing are thereby essential to the control of harmful interference. As there is not a fixed, obvious level of aggregation, or categorically dominant structure of rights partitioning (sometimes called spectrum sharing), the challenge is to discover, implement, and then manage wireless networks over time, as circumstances change. This drives the argument for spectrum markets.

"Given a combination of De Vany-like flexible rights," wrote Timothy Forde and Linda Doyle in a 2007 IEEE conference paper, "DSA [dynamic spectrum access] technology and rational profit-seeking firms competing in a market, there are a number of ways in which these three elements could combine to deal with presence of interference-related externalities."[385] This is a modern restatement of the 1962 Coase, Meckling, and Minasian explanation of how economic incentives and property rights enable the discovery of "optimal combinations."[386] The efficiency logic of the statement works whatever the state of technology options. Indeed, the availability of robust market forces—flexible spectrum use rights held, in efficient bundles, by for-profit rights holders—will itself facilitate the introduction of innovative services and advanced technologies that the process of "creative destruction" uniquely produces. This process relies on these key ingredients:

(a) broad, exclusive rights to control spectrum access;
(b) for-profit licensees with strong incentives to discover the "optimal combinations," internalizing costs and benefits; and
(c) efficient bundles of rights, assembled initially by regulators, in initial auctions, or via secondary markets.

384. *See supra* note 155 and accompanying text (discussing the Nextel spectrum swap).
385. Forde & Doyle, *supra* note 344, at 311.
386. COASE, MECKLING & MINASIAN, *supra* note 37, at 76–77.

The prescription includes the freedom to aggregate or disaggregate exclusive rights, and is strongly supported by competitive bidding for licenses in auctions that include combinatorial bids. Forde and Doyle appropriately focus on the legal and regulatory rules to reduce barriers to efficient market organization when initially issuing rights.[387] They model a market in which dynamic spectrum access—short, numerous bursts—can be accommodated on licensed bands with exclusive rights, with rights aggregation serving to coordinate potentially conflicting activities.[388] They argue that to counter the "inevitable chafing of rights at the boundaries . . . it is possible to reduce, or eliminate, the existence of such externalities through the adjustment and exchange of rights."[389] This leads them to construct auction mechanisms that more easily permit rights to be bundled via the bids of efficiency-motivated agents.[390] Numerous such combinatorial auction mechanisms have been developed in wireless license auctions and in other bidding problems.[391] They form an integral part of an efficient policy response to controlling harmful interference.

This is not generally appreciated. For instance, De Vries and Sieh, concerned with creating "unambiguous" spectrum use rights to counter disputes over airwave interference, propose that FCC rules define probabilistic spillovers.[392] These occur when borders of TAS rights are encroached due to stochastic events, such as atmospheric conditions. But the cost of increasing the complexity of the rights definition process does not influence their policy choice. The alternative to creating more regulatory process to insert, ex ante, probability distributions into defined rights, is to delegate such issues to market packaging. The most damaging and contentious borders, especially those complicated by stochastic natural effects, will tend to be integrated. Less problematic borders—and many fewer of them, to the degree that probabilistic spillovers are an issue—will exist. This general phenomenon has been seen in wireless markets, both with the aggregation of liberal licenses and the gridlock exhibited throughout the economy with interleaving involving illiberal (or government-owned) licenses.[393] A major theme of business structure research is the extent to which firms integrate to overcome the costs of using "the price

387. Forde & Doyle, *supra* note 344, at 311.
388. *Id.*
389. *Id.* at 303.
390. *Id.*
391. Porter at al., *supra* note 144; *see also* COMBINATORIAL AUCTIONS, *supra* note 296.
392. DE VRIES & SIEH, *supra* note 57.
393. Hazlett & Leo, *supra* note 97.

mechanism."[394] The central logic is that companies systemically attempt to build efficient ecosystems around their core businesses. This drives them to coordinate production with complex complementarities *internally*, leaving other firms—operating on fairly simply defined modular interfaces—to provide other inputs or complements *externally*. The competitive process is continually searching for new structural efficiencies, which redefine these product borders.[395]

K. OVERLAYS

The prime task, however, is not to define rights more carefully, but to devise allocation strategies that can allow rational reconfiguration of spectrum usage. Forde and Doyle have made repeated efforts to do that, focusing on devising auction mechanisms that steer initial rights assignments to the parties that can most productively use them.[396] Their approach focuses on the issuance of liberal, flexible-use rights, and efficient distribution using formats like combinatorial auctions.[397] Their approach is to be applauded, as it devotes attention to the relevant margins, delegating the most complex decision-making to competitive, for-profit enterprises.[398]

Regulators must be able to define spectrum rights in the parsimonious way that auctions require, however. In situations where incumbent licensees are already in place, even the availability of abundant unused spectrum resources presents difficulties that have proven insurmountable for administrative allocation. For instance, the TV Band, while little used in the United States since its inception, continues to block very productive opportunities because regulators cannot effectively delineate between the rights of current broadcasters and the (potentially more valuable) rights of new TV Band users.[399]

One set of options is being pursued by the Federal Communications Commission in the form of "incentive auctions." Initially proposed in 2002 by FCC experts Evan Kwerel and John Williams, the basic idea is to

394. The term was used in Ronald Coase, *The Nature of the Firm*, 4 ECONOMICA 386–405 (1937). In this instance, a firm's cost of using the market—what happens when adjacent bandwidth is controlled by regulators and/or rivals, rather than by the firm itself—can be avoided by buying (liberal) licenses.

395. *See, e.g.*, Carliss Y. Baldwin & Kim B. Clark, *Managing in an Age of Modularity*, 75 HARV. BUS. REV. 84 (1997).

396. Forde & Doyle, *supra* note 41.

397. *Id.* at 329.

398. *Id.* (recognizing the computational complexity of an auction mechanism responsive to dynamic adjustments of cognitive participants).

399. Hazlett, *Tragedy TV*, *supra* note 76, at 84.

reallocate some of the television band to mobile services via a pair of auctions.[400] The first would be a reverse auction in which existing TV station owners would state offer prices—what they would accept in payment to exit. With this information, the FCC then proceeds to remove the lowest-priced stations (as per the offers stated in the reverse auction), and to relocate the remaining stations, packing them onto new channels. This process is designed to leave contiguous television spectrum vacant (clear of TV broadcasting), making up to 120 MHz of the 294 MHz available for reallocation to CMRS licenses. These are then sold in a standard forward auction.[401]

The National Broadband Plan, which found that making additional bandwidth available for wireless networks was essential for the U.S. economy, made this policy strategy a key initiative for the FCC with its Report in March 2010.[402] The first hurdle was to obtain a new federal statute empowering the FCC to hold the reverse auction, and to designate the bids from the forward auction to compensate TV stations whose bids were accepted. Congress passed legislation enabling this process in February 2012.[403] The agency is expected to issue its first public notices, with initial discussion of how it intends to structure the upcoming auctions, in late 2012.[404] Actual reallocation of TV Band spectrum is not expected to occur before 2017.[405] The legislation gives the FCC until 2022 to conduct an auction.[406]

An alternative proposal to reverse auctions was the use of an "overlay" auction.[407] While it was rejected by the FCC,[408] the Commission, particularly

400. *See* Kwerel & Williams, *supra* note 42, at 33.

401. For more on issues related to a reverse auction and forward auction stages of the incentive auction, see HAZLETT ET AL., INCENTIVE AUCTIONS PAPER, *supra* note 49.

402. NBP 2010, *supra* note 3, at 75.

403. MIDDLE CLASS TAX RELIEF ACT AND JOB CREATION ACT of 2012, P.L. 112-96, 126 STAT. 156, 47 U.S.C. § 1451 (authorizing the FCC to conduct incentive auctions with forward and reserve auction components for broadcast TV spectrum).

404. *Id.*; *see generally* FCC, *Incentive Auctions* http://www.fcc.gov/topic/incentive-auctions (last visited Oct. 18, 2012).

405. FCC, *Incentive Auctions*, *supra* note 404; 2012 Incentive Auction NPRM, *supra* note 49. Reply comments to the Notice for Proposed Rulemaking are due February 2013, when the FCC will release a Report & Order estimated in 2014, with implementation by 2017. 2012 Incentive Auction NPRM, *supra* note 49.

406. 2012 Incentive Auction NPRM, *supra* note 49, at 12,371.

407. Hazlett, *A Proposal for an Overlay Auction*, *supra* note 50. A recent proposal in the European Union advocates a similar policy approach. PIER LUIGI PARCU ET AL., AUTHORIZED SHARED ACCESS: AN INNOVATIVE MODEL OF PRO-COMPETITIVE SPECTRUM MANAGEMENT (Studio Economico Parcu & Associates 2012), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2174518.

in the use of PCS and Advanced Wireless Services ("AWS") licenses, has employed this method previously.[409] In the use of PCS, regulatory gridlock deterred 2G digital phone services in the United States because, while the FCC had selected a band to be used for the new service, the chosen band was littered with about 4,500 microwave licensees.[410] These operations, which provided point-to-point communications for public utilities, off-shore oil drilling rigs, railroads and other users, consumed very little spectrum.[411] But they provided important services related to public safety, and thus any regulatory action to relocate such communications (either by substituting other spectrum for their wireless links, or by switching to fiber optic lines) was greeted with intense opposition.[412] The allegation was that relocation would directly impact operations involving "safety of life and property" if the incumbent uses were compromised in any way.[413]

The solution, after years of regulatory stasis, was to assign PCS overlay rights by competitive bidding,[414] providing new licensees with flexible use of the allocated spectrum (30 MHz for A, B, and C block licenses; 10 MHz for E, F, and D; 120 MHz in total).[415] But existing microwave users were vested,[416] and could continue operating as they had been. Meanwhile, the new

408. While the NBP explicitly endorsed the "incentive auction" policy as its first choice, it recommended overlays as a possible back-up plan: "Explore alternatives—including changes in broadcast technical architecture, an overlay license auction, or more extensive channel sharing—in the event the preceding recommendations do not yield a significant amount of spectrum." NBP 2010, *supra* note 3, at 88.

409. Overlay auctions have also been considered in the United Kingdom. *See* Cave, *supra* note 251, at 81–82.

410. *See* 1993 Broadband PCS Second R&O, *supra* note 104; *see also* Cramton et al., *supra* note 122.

411. *See* 1993 Broadband PCS Second R&O, *supra* note 104.

412. Cramton et al., *supra* note 122, at 17.

413. *See, e.g.*, Reply Comments of Association of Public-Safety Communications Officials-International, Inc., Amendment to the Commission's Rules Regarding a Plan for Sharing the Costs of Microwave Relocation, WT Docket No. 95-157, at 7 (Jan. 1, 1996), http://apps.fcc.gov/ecfs//document/view.action?id=1537490001 ("Nor should public safety incumbents ever be exposed to the potential of being forced to relinquish critical communications frequencies without assurances of receiving comparable facilities at no cost to taxpayers.").

414. *See* Cramton et al., *supra* note 122, at 660–61.

415. *See generally* 47 C.F.R. 24.701 (2000) (broadband PCS subject to competitive bidding); In the Matter of Amendment of Part 1 of the Commission's Rules—Competitive Bidding Procedures, Order on Reconsideration of the Third Report & Order, Fifth Report & Order, and Fourth Further Notice of Proposed Rulemaking, 15 FCC Rcd. 15,293, 15,331 (2000), *available at* http://www.fcc.gov/Bureaus/Wireless/Orders/2000/fcc00274.doc.

416. *See* 1993 Broadband PCS Second R&O, *supra* note 104, at 7706.

PCS licensees were obligated to avoid creating harmful interference that would damage their operations.[417]

This created a new dynamic. Instead of maintaining a political position that no change was possible, incumbents now faced real opportunity costs. If they relocated, they would provide valuable new bandwidth to the PCS licensee authorized to use it; maintaining their intransigence would no longer be free. On the other hand, the overlay licensees—who had secondary rights to use the spectrum allocated through the incumbents' licenses—also had straightforward economic choices. Either the overlay licensees could work around the incumbents' transmissions, or else buy them out. Either path was costly, and overlay licensees naturally preferred the least costly path. Hence, both sides had proper incentives to find efficient solutions.

The fact that many of the microwave incumbents were non-profit or rate-of-return regulated enterprises complicated the negotiations between incumbents and overlay licensees, because the incumbents were less motivated by cash payments than businesses seeking to maximize profits.[418] To offset this lack of economic motivation, regulators alertly supplied additional incentives, mandating good faith negotiations for relocation, placing responsibility on overlay owners to pay for incumbents' moving costs, and then imposing time limits.[419] A similar set of overlays and circumstances was obtained in 2006 with the auctioning of AWS licenses. In this case, incumbent wireless users were largely government agencies,[420] and hence, market deals were simulated. Overlay (AWS) licensees were mandated to pay the full costs of relocating incumbents, and the FCC adjudicated disputes over terms.[421]

In both instances, the process worked—not perfectly, but ostensibly better than administrative allocation. Without overlay owners initiating deals and paying relocation costs, it has proven virtually impossible for the FCC to reallocate large numbers of incumbent wireless users to clear broad swaths of spectrum.[422] Reallocation has costs of its own, including those associated with regulatory gridlock.

---

417. 1993 Broadband PCS Second R&O, *supra* note 104, at 7755, 7767.

418. *See generally* 1993 Broadband PCS Second R&O, *supra* note 104.

419. *See* 2004 U-PCS NPRM, *supra* note 102, at 5126–27 (describing UTAM, Inc. case, where a separate entity facilitated negotiation among parties).

420. *See* NTIA, Relocation of Federal Systems in the 1710–1755 MHz Frequency Band, *infra* note 435, at 2.

421. *See id.*

422. NBP 2010, *supra* note 3, at 90 (recommending Congressional authority for incentive auctions). The FCC could not otherwise reallocate the TV band without a legislative grant of authority. *See* 2012 Incentive Auction NPRM, *supra* note 49 (describing

TV Band overlays could improve upon both past and current spectrum allocation efforts. By enabling private, for-profit enterprises with the rights to claim the residual value of whatever new opportunities they create, they will seek to develop efficient, cooperative bargains with TV broadcasters. In securing alternative video distribution platforms for their content, finding innovative ways to compress broadcast TV signals, and accommodating more intense sharing of channels, overlay owners would stand to reap very substantial rewards—as much as $50 billion or more—by reducing low-valued uses of the TV Band in favor of higher-valued services.[423] Of course, the government could capture much of this gain in overlay license auctions, but the social welfare gains are likely to be many times the magnitude of the producers' surplus.[424]

The FCC chose a different policy approach based on their view of transaction costs:

> Incentive auctions present a more efficient alternative to the FCC's overlay auction authority, in which the FCC auctions encumbered overlay licenses and lets the new overlay licensees negotiate with incumbents to clear spectrum. These piecemeal voluntary negotiations between new licensees and incumbents introduce delays as well as high transaction costs as new licensees contend with holdouts and other bargaining problems. Anticipating these delays and negotiating costs, bidders typically pay significantly less for encumbered spectrum. The value of spectrum that must be cleared through such a voluntary process is reduced even more by uncertainty about the final cost of clearing.[425]

However, the FCC's argument is both incomplete and not compelling. Private market negotiations entail costs just like government reallocation efforts. The latter are not considered in any serious way, an approach that smacks of the Nirvana Fallacy.[426]

---

the incentive auction NPRM); MIDDLE CLASS TAX RELIEF ACT AND JOB CREATION ACT of 2012, P.L. 112-96, 126 Stat. 156, 47 U.S.C. § 1451.

423. *Tragedy TV*, *supra* note 76, at 112 n.154 ("The Federal Communications Commission estimates the spectrum's value at between $20 billion and $132 billion.").

424. *See* discussion *supra* Section III.E (discussing consumer surplus).

425. *NBP 2010*, *supra* note 3, at 82.

426. Demsetz writes:

> The view that now pervades much public policy economics implicitly presents the relevant choice as between an ideal norm and an existing "imperfect" institutional arrangement. This *nirvana* approach differs considerably from a: *comparative institution* approach in which the relevant choice is between alternative real institutional arrangements. In practice, those who adopt the nirvana viewpoint seek to discover discrepancies

Two obvious heavy burdens are already visible, even if they have not yet become apparent to the FCC. First, the incentive auction program is regulation-intensive. A two-year delay[427] was incurred as new authority was sought from Congress following the issuance of the National Broadband Plan. The eventual authorization includes provisions that the FCC did not ask for and did not want,[428] as it will reduce the amount of spectrum that can be reallocated while simultaneously increasing the probability that litigation from disgruntled broadcast station owners will mire the entire transition in legal process.[429] Overlays, in contrast, are standard forms that could have been defined, allocated, and auctioned years ago, without new Congressional authorization.

Second, despite whatever impediments negotiations between incumbents and overlay licensees may entail, the FCC implicitly concedes that its alternative path of incentive auctions is strewn with obstacles. This is the clue embedded in the "incentive auction" plan to reallocate approximately 40% of the TV Band, or 120 MHz of the 294 MHz.[430] A more sweeping transition involving all 294 MHz could be priced by overlay licensees based on relevant market data. But the FCC policy will continue to use spectrum having very high social opportunity costs to park off-air broadcast stations, a service that provides little if any incremental value beyond what cable, satellite and broadband platforms can deliver on their own. These costs, unseen as

---

> between the ideal and the real and if discrepancies are found, they deduce that the real is inefficient. Users of the comparative institution approach attempt to assess which alternative real institutional arrangement seems best able to cope with the economic problem . . . .

Demsetz, *supra* note 239, at 1 (emphasis in original).

427. The delay is actually much longer, given that a reallocation via overlays could have begun in 2009 (when the NBP was being written) or sooner.

428. Indeed, the head of the NBP, Blair Levin, has argued that the provisioning legislation was a disaster that threatens the entire program.

> "The legislation ties the FCC's hands in a variety of ways," said Levin, who left the FCC following release of the broadband plan and is now attached to the Aspen Institute. "It opens it up to litigation risk, which then, in conjunction with the other handcuffs, makes it difficult to pull off a successful auction. The nature of the bill dramatically increases the probability that there will be less spectrum recovered and less money for the [U.S.] Treasury."

Kim McAvoy, *Levin: TV Spectrum Auctions Likely Doomed*, TV NEWSCHECK (Jan. 5, 2012), http://www.tvnewscheck.com/article/56476/levin-tv-spectrum-auctions-likely-doomed.

429. *See* Hazlett at al., *Incentive Auctions Paper*, *supra* note 49, at 4, 6 (on the repacking compensation determined in administrative process, with anticipation of results to be "vigorously challenged" by stakeholders).

430. Hazlett, *A Proposal for an Overlay Auction*, *supra* note 50; *Incentive Auctions*, *supra* note 49; 2012 Incentive Auction NPRM, *supra* note 49.

unrealized opportunities, exhibit the classic regulatory bias in favor of "Type II error."[431]

The evidence that the Commission draws on for its conclusion is lacking. That Commission draws attention to "holdouts" and "bargaining problems," but does not recognize the similar issues in its own regulatory actions. Moreover, it fails to understand that market actors have been quite successful in overcoming similar obstacles in the past. The FCC has, after all, fragmented mobile license rights beyond imagination, issuing *well over 50,000 licenses*.[432] These rights have been aggregated into somewhere between four and seven national wireless networks over the past several years. Much of the reassembly was accommodated by the adoption of license auctions, for which regulators—at least those sufficiently farsighted to push Congress to enable this policy as it did in 1993—deserve credit. Yet, the great majority of the consolidation took place in secondary market transactions where every merger overcame a potential "holdout" problem. Hence, the evidence presented does not support the FCC's position.

The general utility of the overlay approach recommends it highly. Overlays may be issued for bands with existing users, including for-profit and non-profit (including government) licensees. These new rights can and generally should be auctioned, thereby introducing responsible economic agents into the markets in the form of rights holders positioned to efficiently reallocate spectrum in the band. Users and their business models can be reorganized, frequency assignments may be switched, new technologies may be deployed, and ultimately the optimal combinations for wireless activities that reflect current conditions and opportunities can be discovered. The "relocations" that occur will be strictly voluntary, mutually beneficial contractual bargains that generate net benefits for all parties involved. Cooperation replaces conflict; spectrum repurposing moves forward; regulatory quagmires are avoided.

This process has been shown to work using standardized rights templates across diverse situations. Scores of TV stations went dark early (prior to the June 2009 analog station switch off) to accommodate Qualcomm's use of TV spectrum for a new service, MediaFlo, in 2006 to 2008.[433] The approach

431. *Wireless Craze*, *supra* note 30, at 380–82 & fig.5 (discussing social costs and benefits of spectrum use, type II error of underuse, type I error of overuse, and the tragedy of the uncommons).

432. *Federal Preemption*, *supra* note 29, at 194, 201.

433. Thomas W. Hazlett, *A Law and Economics Approach to Spectrum Property Rights: A Response to Professors Weiser & Hatfield*, 15 GEO. MASON L. REV. 975, 999–1002 (2008). In fact, even though MediaFlo resided on Channel 55, estimates of as many as one in six terrestrial broadcasting stations were reconfigured, including in neighboring Channels 54 and

worked very well in PCS licensing, where the overlay concept rescued government spectrum allocation policy that had been mired in a long-running dispute over PCS-microwave interference. And, this approach also worked for AWS licenses, where public agencies had delayed, since at least 1992,[434] in making room for new wireless communications. After licenses were auctioned in September 2006, high bidders—including T-Mobile, which purchased the largest package of rights—emerged to push reallocation forward.[435] These new overlay licensees were obligated to pay for incumbent relocation, and had adjusted their auction bids to reflect anticipated costs.[436] But, as residual rights holders in the band, they actively pushed the process forward.[437] Even with government agencies providing little enthusiasm for the needed changes (which was not surprising given their lack of an

56. *Id.* at 1002; *Tragedy TV*, *supra* note 76, at 110. Such private reconfiguration occurred prior to mandated deadlines.

434. This is when federal legislation designating that the frequencies used for Advanced Wireless Services were authorized for reallocation to commercial mobile services. In 2001, a notice for proposed rulemaking for AWS below 3GHz was released by the FCC, following proposals and requests in the 1992 *Emerging Technologies Proceeding* (ET Docket No. 92-9), which identified possible bands for advanced wireless devices. *See* Press Release, FCC, FCC Looks to Allocate Additional Spectrum for New Advanced Wireless Systems (Jan. 4, 2001), http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-208768A1.pdf. In November 2003, new service rules were promulgated for this AWS spectrum, auctioned in Auction #66 in 2006. However, AWS spectrum slated for auction in 2011 has missed deadlines, and statutorily must be auctioned by 2015. *See* MIDDLE CLASS TAX RELIEF ACT AND JOB CREATION ACT of 2012, P.L. 112-96, 126 STAT. 156, 47 U.S.C. § 1451 (2011) (setting a 2015 deadline for auction for AWS-2 (1915–1920 MHz, 1995–2000 MHz), AWS-3 (2155–2180 MHz), provided that the bands can be "used without causing harmful interference to commercial mobile service licensees" in 1930–1995 MHz).

435. Comments of T-Mobile USA, Inc., Relocation of Federal Systems in the 1710–1755 MHz Frequency Band: Review of the Initial Implementation of the Commercial Spectrum Enhancement Act, Docket No. 0906231085-91085-01, at 2 (Nat'l Telecomms. & Info. Admin., Aug. 21, 2009), http://www.ntia.doc.gov/files/ntia/t-mobile_csea_noi_comments_8-21-09_0.pdf.

436. *Id.* at 8 (describing the quality of information provided by federal agencies on incumbent uses: "Because several agencies underestimated the cost and time involved in relocation, prospective bidders, including T-Mobile, received inaccurate projections about when the spectrum would be commercially available."); *id.* at 9 ("Prior to the auction, AWS bidders were given only a limited amount of information about the incumbent systems: agency name, center frequency, system type and name, and coordinates for transmitters and receivers."); *id.* at 10 ("As noted above, much of the data compiled by federal agencies and provided to prospective licensees was incomplete or inaccurate and impeded licensee requests for early access to spectrum. In some cases, initial cost-estimates were so off the mark that the additional requests for funds from OMB triggered Congressional review, stalling efforts for early access to the spectrum and further delaying service to consumers.").

437. *See id.* at 10 ("It was only after the auction that carriers learned these 12 assignments barred use of the entire AWS and, causing significant delays in launching commercial service.").

economic stake in the outcome), the presence of interested parties with important assets at stake produced progress. By the end of 2008, T-Mobile offered 3G services to consumers using the AWS spectrum.[438]

The overlay approach delegates the process of reallocation to specialized agents. In lieu of disinterested parties attempting to liquidate existing band users to make way for new uses, private parties received a claim to their newly created values. The normal economic incentives drive these parties to obtain information, innovate in the technologies and market organization employed, and discover new ways of lowering the exit costs for incumbents. In these pursuits, parties are not hamstrung by bureaucratic procedures, but can avail themselves of the full line of efficiency-enhancing institutions created for such purposes—including capital markets. With ready funding for value-creating projects, financial investors can pay to liquidate the obstacles that need to be removed to make way for greater economic gains. With "incentive auctions," policy makers now attempt to mimic the market. The success or failure of incentive auctions will be a fitting experiment.

V. CONCLUSION

It is clear that existing spectrum allocation rules deter the productive use of a key natural resource in the information economy. Yet a tantalizing series of natural experiments shows a more productive path for allocating spectrum. Amazing new wireless applications have emerged using the modest bandwidth allotted to liberal licenses. With these airwaves, used according to market demands, networks have formed that are revolutionizing communications, forging new paths to economic development, and discovering geysers of value in emerging social media. But the success of such wealth-creating innovations frustrates policy makers, tasked with the challenge of supplying spectrum inputs to this rapidly scaling marketplace.[439]

438. Press Release, T-Mobile, T-Mobile USA Announces Commercial 3G Network Availability in 21 Markets by Mid-October (Sept. 18, 2008), *available at* http://newsroom.t-mobile.com/articles/t-mobile-3G-network-availability (describing deployment of 3G service to twenty-seven major markets, on UMTS/HSDPA technology). Regarding AWS, "T-Mobile and the U.S. government, namely the Department of Commerce, Department of Defense and the Department of Justice, continue to work closely and effectively together to make available AWS spectrum that will give our customers access to T-Mobile's 3G network." *Id.*

439. "[B]y estimating various factors . . . mobile broadband is likely to entail economic value of at least $100 billion in the next five years." FCC, MOBILE BROADBAND: THE BENEFITS OF ADDITIONAL SPECTRUM 5 (Oct. 2010), *available at* http://download.broadband.gov/plan/fcc-staff-technical-paper-mobile-broadband-benefits-of-additional-spectrum.pdf (listing

While virtually swimming in little-used, under-deployed frequency bands, each and every attempt spectrum regulators make to move additional bandwidth into more productive use is met with fierce resistance. The prospect of harmful interference inevitably looms whenever the effort is to increase wireless deployments; the additional traffic yields benefits (new uses) but also costs (crowding old uses). Under the administrative allocation system defined by the 1927 Radio Act, regulators are charged with determining the proper balance. The general scholarly dissatisfaction with the operation of this system is that regulators, on net, are decidedly prone to protect the existing order. Change is too difficult. The beneficial wireless uses that are blocked in order to prevent possible airwave conflicts with existing services errs far too much on the side of silence.

The dysfunctional nature of the Federal Communications Commission—documented by the Commission itself, in charting the socially expensive delays incurred in allocating or reallocating spectrum—has given rise to academic discussion as to how best to break the logjam. Many analysts (and the Commission) point out that spectrum markets, to be efficient, depend on spectrum use rights that are defined "clearly and exhaustively." They bemoan the fact that this has never been done by regulators. From there, they conclude that this task must be completed and that spectrum markets demand greater specificity in the delineation of property rights. They proceed to blame long-standing interference disputes, arguments that have seemingly delayed valuable reallocations of bandwidth for years, on the lack of full, precise, unambiguous delineations of the boundaries of spectrum use rights.

This policy response, as we have attempted to show, is wrong. Exclusive use rights for mobile service licensees are not defined precisely and do not preempt all possible disputes—not nearly. But they have proven "good enough." They are sufficient to organize very active markets, filled with complex economic relationships and innovative forms of social coordination, and do so in a way that could be accomplished via alternative rules—most pointedly, administrative allocation of radio spectrum. The liberal licenses used in these markets encourage and enable the creation of complementary assets making the spectrum used far more valuable than it would otherwise be. Yet the ownership rights are not exact. Indeed, they cannot be exact; fortunately, they do not need to be. They must simply beat the alternatives.

One alternative is for spectrum allocation to proceed, blocking current deployments, as regulators search for more exact rights specifications. This

mobile statistics such as economic impacts, tablet sales, mobile application sales, mobile online commerce, and social value in education and health care).

has happened in many markets, with generally disastrous consequences for consumer welfare. Take the L Band, used for satellite services.[440] An operator there, a decade ago, sought to increase the value of services provided by rearranging the band and supplying terrestrial mobile voice and data connections in addition to satellite links. The extra traffic would make noisy what was very quiet. Objections were heard. A large number of technical reports, some reporting results of field tests, evaluated how new L Band traffic would impact the reception of GPS signals using adjacent frequencies. The decisive moment arrived when the U.S. Department of Commerce sent the FCC a letter stating that the performance of GPS receivers—some used for emergency navigation warnings on airplanes, other used by the U.S. military—would be, on some occasions, degraded. Commerce strongly argued that no terrestrial L Band operations be permitted, a position backed by the Federal Aviation Administration and the Department of Defense.[441] The FCC immediately determined that harmful interference would best be avoided by leaving the L Band quiet, killing the authorization for terrestrial service and ending what was to be a $14 billion mobile communications network.[442] Disinterested observers appalled by the decision and the process dismissed the regulatory choice as political.[443]

That tempest is a microcosm of FCC dysfunctionality. An intense debate looms among the technical experts. But their voluminous engineering data decide nothing. They do not—and cannot—determine the "proper" spectrum use, which depends on competing values. (*How much would entice GPS users to tolerate 8 dB of signal interference? Perhaps free new GPS receivers plus LTE 4G unlimited data subscriptions?*) The decision as to resource use is then made by administrators who, after reading technical reports, make a political choice—but in actuality render an *economic decision*.

---

440. The fascinating and quite complicated story of the "LightSquared debacle" is discussed in detail in Thomas W. Hazlett & Brent Skorup, *Tragedy of the Regulatory Commons: LightSquared and the Missing Spectrum Rights*, 11 DUKE L. & TECH. REV. (forthcoming 2013).

441. Letter from Lawrence E. Strickling, Assistant Secretary for Communications and Information, to Julius Genachowski, Chairman, Federal Communications Commission, U.S. Dep't of Commerce (Feb. 14, 2012).

442. Statement From FCC Spokesperson Tammy Sun on Letter from NTIA Addressing Harmful Interference Testing Conclusions Pertinent to LightSquared and Global Positioning Systems (Feb. 14, 2012). The $14 billion expenditure included construction costs for physical infrastructure and spectrum acquisition costs, including payments to other satellite licensees in the L Band. *See* Statement from Sanjiv Ahuja, CEO of LightSquared (Dec. 14, 2011), *available at* http://www.prnewswire.com/news-releases/statement-from-sanjiv-ahuja-ceo-of-lightsquared-35621603.html.

443. Telecoms in America, *A Dark Day for Lightsquared, Plans for a New National Wireless Network Hit a Regulatory Wall*, ECONOMIST, Feb. 18, 2012, http://www.economist.com/node/21547813.

To improve social welfare, public policy must be restructured. Technical specificity is worth including when it is worth its cost, but extremely damaging to pursue when it is not. Moreover, it both binds and blinds the institutional process. Great activity occurs of an analytical nature—indeed, it looks like administrative fact-finding to courts sitting in review. But greater exactitude in rights delineation is rarely the problem in spectrum allocation. The key issues do not involve what signals interfere but what economic plans interfere, and there exist myriad ways in which to make the conflicting plans coincide. But these win-win pathways are truncated by the lack of ownership rights that regulators—instead of pursuing fruitless harmful interference dockets—should be defining and setting adrift, delegating spectrum use decisions to responsible economic agents who experience opportunity costs in real-time, who prosper when they are right and suffer when they are wrong.

When the margins of use rights are in doubt, conflicts are generally solved—in the market or by regulators—not with greater exactitude but with reconfiguring ownership rights. This eliminates fragmentation, such as the notorious "interleaving" allocations, so as to "reallocate" spectrum. Withholding rights from the market, by issuing "operating permits" in lieu of "spectrum licenses," ensures that a great deal of productive spectrum activity is little more than alternative applications locked in the vaults of regulators. In this situation, licensees do not strive to maximize the use of the spectrum allocated, in that they incur no opportunity costs from doing what is socially inefficient. They cannot be paid to perform any better. By eliminating these anti-social rights truncations, and putting all flexible-use rights into the bundles managed by licensees, liberalization enables activity by way of privatized coordination in wireless. When the right of transfer is properly included, secondary markets are enabled and market forces naturally resolve the problems of fragmentation.

Of course, to mitigate transaction costs, regulators should properly assign rights in the first place. In that regard, the introduction of competitive bidding to assign licenses—adopted in dozens of countries over the past quarter-century—are a welcome policy innovation. Including combination bids would improve that mechanism. In general, aggregations of license rights provide for rational choices to be made about "interference," which is internalized, as well as for partitioning, which should be a permissible activity.

There is no need to reinvent the wheel. Reasonable packages of spectrum use rights have been created by regulators and deployed in the market, enabling efficient service delivery. They have not only accommodated investment and commerce, but waves of innovation. The "smartphone

revolution" has been launched using liberal mobile phone licenses, and has in turn introduced mobile phone application platforms that disrupt old business models by offering greatly expanded sources of services and content. No new government authorizations or requests for permission for new network applications were needed. New applications could have created harmful interference between mobile phones—indeed, they certainly did when crowded networks slowed to a crawl at peak times. But carriers compete to manage these flows, to protect their quality of service, and to welcome fancy new consumer-pleasing gadgets with sophisticated computing bundled within.

Economics governs spectrum. That simple maxim can, and should, better inform our governing choices.