Spectrum Tragedies

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Recent research into "common interest tragedies" helps clarify the costs and benefits of radio spectrum regulation. In traditional allocations involving licensed spectrum, regulators truncate licensee rights, which, while inter-dependent, are widely dispersed, often leading to a tragedy of the anticommons. With allocations for unlicensed spectrum, regulators impose open access rules, often leading to a tragedy of the commons. Both forms of market failure trigger anticipations that undercut investment incentives, deterring socially useful services—a common interest tragedy, redux. In contrast, liberalization of property rights in wireless telephony appears to avoid costly tragedies. Decentralized market incentives succeeded in bringing over $150 billion in financial capital to provide services over spectrum shared by more than 170 million subscribers; annual consumer surplus is conservatively estimated to exceed $80 billion. Marginal valuations appear to far exceed the social value of spectrum use under alternative forms of organization. This empirical reality is not well integrated into regulatory decision-making, however, as administrative rulemakings fail to properly consider the efficiency implications of common interest tragedies, even as stated rationales for spectrum rules reflect such tragedies.

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III. Conclusion

Introduction

The "tragedy of the commons" has had a long relationship with radio spectrum, but misapplication of the concept has gotten the lion's share of publicity. That is due to the mindshare boost afforded the "chaos" theory of airwaves in Felix Frankfurter's opinion in NBC v. United States, a case brought by a radio network asserting its First Amendment rights against government regulation. The Supreme Court found that broadcasters were licensees who were privileged to communicate via radio waves, enjoying substantially fewer free speech rights than would a newspaper printing its ideas on paper. The ruling rested upon the finding that prior to government frequency allocation there existed a "cacophony of competing voices"—the audio rendition of the tragedy of the commons.

Ronald Coase's 1959 inquiry into how radio waves were allocated by the Federal Communications Commission was targeted at Justice Frankfurter's view of the radio market. Coase showed that the key to orderly development of wireless communications was not spectrum allocation by the government or licensing of broadcasters under the "public interest" standard, but the issuance of clearly delineated spectrum rights. Such rights could be distributed by market forces just as other inputs (e.g., newsprint and ink) in other markets. In fact, the rights associated with broadcasting licenses were routinely traded in secondary markets. Coase saw "government control" of radio spectrum was

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1 319 U.S. 190, 212 (1943).
2 The Court reasoned that: Freedom of utterance is abridged to many who wish to use the limited facilities of radio. Unlike other modes of expression, radio inherently is not available to all. That is its unique characteristic, and that is why, unlike other modes of expression, it is subject to governmental regulation. Because it cannot be used by all, some who wish to use it must be denied.
3 Id. at 226.
4 This phrase actually dates to the Supreme Court's 1969 opinion in Red Lion Broadcasting Co. v. FCC, 395 U.S. 367 (1969), which (extending the NBC opinion) upheld government regulation of radio and TV broadcasters under the rubric of the "fairness doctrine." The relevant passage reads: Before 1927, the allocation of frequencies was left entirely to the private sector, and the result was chaos. It quickly became apparent that broadcast frequencies constituted a scarce resource whose use could be regulated and rationalized only by the Government. Without Government control, the medium would be of little use because of the cacaphony of competing voices, none of which could be clearly and predictably heard.
5 Id. at 375-76 (footnotes omitted).
6 Id. at 12-13.
7 Id. at 20-21.
8 Id. at 14.
neither necessary nor sufficient for economic development. What satisfied both conditions was the creation and enforcement of property rights.

This analysis led economists to generally reconsider how markets allocated resources involving spillovers. As articulated the following year, the Coase Theorem logically demonstrated that resources would be efficiently allocated if rights to property were well-defined and the cost of trading these rights was modest. This moved the default efficiency rule (in economic analysis) from one of administrative resource allocation to decentralized market allocation. This had been the default rule for markets without external costs or benefits; Coase’s analysis generalized that result to show how its applicability rested on rights rather than economic interdependencies. Where rights are clearly delineated, costs (or benefits) imposed on other parties are taken into account by those who produce such costs (or benefits), and efficient solutions naturally obtain.

Despite the wealth of economic insight yielded in this laboratory, radio spectrum policy has largely resisted its implications. The proposal that wireless licenses were better assigned by competitive bidding than by fiat was adopted in the United States in 1993. Yet, in all but a small number of countries, airwave use rights are still severely truncated. Spectrum is allocated according to “public interest” criteria. As FCC policy analysts Evan Kwerel and John Williams explain:

In the United States spectrum is currently managed by administrative process. Licenses not only define the amount of spectrum (in frequency, time, and space) but narrowly specify the services licensees may provide and the technologies they may use. For example, a television broadcasting license entitles the licensee to provide only television service. The licensee may not, for example, use its spectrum for cellular telephone service, even if it is technically feasible to do so without interfering with other licensees.

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8 Id. at 21-22.
13 Evan R. Kwerel & John R. Williams, Moving Toward a Market for Spectrum, 16 REGULATION, No. 2, at 53, 53 (1993). In the intervening decade, more liberal rules have been adopted for cellular telephone licenses (including licenses issued to personal communications service (PCS) entrants in 1995-96), creating an important—but specifically limited—exception to the rule. Subsequently, the authors have found that about 7% of the radio spectrum below 3 GHz is available to licensees under flexible use rules. This is the allocation to commercial mobile radio services (CMRS) licenses, which includes cellular, PCS, and specialized mobile radio (SMR). EVAN KWEREL & JOHN
Regulators generally determine how particular blocks of spectrum can be used, employing allocation rules to define what rights are made available to licensees or unlicensed users. These rules go far beyond the delineation of boundaries between users, restricting technologies, power, transmitter locations, business models, and services. Hence, “spectrum auctions” are a misnomer; the price system is used to assign operating licenses that restrict the use of radio spectrum to a specific, regulated employment.

The result of this administrative allocation is a panoply of “common interest tragedies,” spanning “tragedy of the commons” and “tragedy of the anticommons.” The former is thought to obtain when ownership rights are not well established, and parties have overly strong incentives to appropriate value from an asset. The result is over-use of a resource, resulting in its dissipation—the familiar “over-grazing” problem. The anticommons tragedy is thought to produce the reverse (although Fennell has clarified this approach, categorizing the tragedies as two sides of the same coin). With an anticommons, private ownership rights are well established, but they are so fragmented that efficient aggregation is difficult—under-use prevails.

Here the symmetry of the “tragedy” is seen: anticipations of inefficient over-use of spectrum (associated with the tragedy of the commons) causes financial markets to under-invest in technology and networks (a result associated with the tragedy of the anticommons). This two-sides-of-the-coin analysis extends to non-market failure: in anticipating that unpriced, license-unavailable spectrum will be efficiently used, financial markets under-invest in networks.


15 The error is seen in this recent statement in The Economist, which awarded one of its 2003 “Innovation Awards” to Ronald Coase:

In papers published in 1959 and 1960, Dr. Coase asked why valuable radio spectrum was going to waste. He suggested that the problem was the lack of private property rights over spectrum, which prevented the formation of a market to allocate spectrum efficiently. The answer, he proposed, was to open the allocation of radio spectrum to market forces. His proposal was derided, but radio spectrum is now routinely allocated by auction...

And the Winners Were... ECONOMIST, Dec. 6, 2003, at 15, 15 (emphasis in original). While the description of Coase’s work is accurate, the assertion that “radio spectrum is now routinely allocated by auction,” id., is not.

16 Some important exceptions exist, both in the United States and internationally. See Hazlett, supra note 14; HAZLETT, supra note 12; KWEREL & WILLIAMS 2002, supra note 13.

17 Lee Anne Fennell nicely explains how a fragmentation of ownership interests drives both tragedy of the commons and tragedy of the anti-commons. See Lee Anne Fennell, Common Interest Tragedies, 98 NW. U.L. REV. 907 (2004).

18 Garrett Hardin, Tragedy of the Commons, 162 SCIENCE 1243 (1968).

exempt access to spectrum will yield a tragedy of the commons, regulators impose regulations (e.g., power limits on transmitting devices) that help police traffic, but in so doing eliminate the opportunity to use spectrum with alternative approaches (e.g., high power emissions), potentially resulting in inefficient under-utilization.

This paper explores two families of spectrum tragedies in a preliminary analysis that will hopefully stimulate further research on the law and economics of spectrum allocation regimes. These are summarized as:

- **Licensed spectrum's tragedy of the anticommons.** Unoccupied bands are observed immediately adjacent to spectrum hosting brisk business, suggesting (if not proving) resource misallocation. Inefficiencies result from the inability of private users to acquire the rights necessary to productively utilize spectrum, and are demonstrably remedied by expanding the scope of rights to use the spectrum allocated to their licenses. This mitigates rights-fragmentation, and under-use, associated with the tragedy of the anticommons. The goal of liberalization is an efficient (input) market in radio spectrum. This is further explored in Part I.

- **Unlicensed spectrum's tragedy of the commons.** The allocation of “open access” spectrum is accompanied by non-market coordination, which the government largely supplies through regulation of wireless devices. This organizational structure works best when satisfying demands for very localized and/or sporadic radio applications. In this setting, rivalry for spectrum space is relatively lax, and blunt instruments (such as power limits on emissions) permit many useful applications. When more extensive spectrum conflicts arise, as in wide area networks, consumers demand more complex spectrum sharing arrangements. Government imposition of coordinating rules in this environment run a higher risk of causing over-use or under-use; anticipation of either prompts under-investment in complementary facilities. This is further explored in Part II.

Understanding how common interest tragedies impact spectrum use, and how mitigation techniques involve costly trade-offs, informs regulatory policy in the wireless sector. These issues have very substantial implications for social welfare and are examined in Part III.
I. Licensed Spectrum’s Tragedy of the Anticommons

A. Moscow Streets on a Spectrum Analyzer

Consider a resource misallocation identified by the Federal Communications Commission, one which is strikingly reminiscent of the “tragedy of the anti-commons” offered by Michael Heller. In Heller’s seminal paper, the brisk business observed at Moscow’s sidewalk kiosks shortly after the fall of Communism, sharply contrasted with the barren look of grand buildings just a few meters away. Block after block of such impressive potential storefronts went vacant, even as demand for floor-space appeared strong. Heller’s explanation was that the rights to use the more accommodating office space were effectively blocked because they had been distributed to multiple parties with conflicting interests. Transaction costs, and in particular hold-out problems, made the assembly of valuable rights difficult.

The picture of vigorous economic activity occurring in one spot, against a curious absence of economic activity immediately adjacent, has also been observed by the FCC:

To assess actual spectrum use, the FCC’s Enforcement Bureau measured spectrum use below 1 GHz in Atlanta, Chicago, New Orleans, San Diego, and in a Washington, DC suburb during various periods in July 2002. These preliminary measurements indicate that, while some bands are heavily used – such as those bands used by cellular base stations – many other bands are not in use or are used only part of the time.

Just as on the Moscow street, the U.S. wireless market sees one band intensely used here, while another is used barely at all even as its frequency space is right next door. This stems from the numerous misallocations inherent in the central planning of radio spectrum, what the FCC dubs “command and control,” and what Professors Faulhaber and Farber more colorfully label “Gosplan.” Further, by issuing inflexible spectrum use rights, regulators have prevented market transactions from diverting bandwidth to services that are more valuable than those the regulators themselves envisioned.

20 Id.
21 Id. at 633-34.
22 Id.
23 Id. at 635-40.
24 Id. at 637-40, 677.
25 SPTFR 2002, supra note 14, at 10 (footnote omitted).
26 Id. at 16.
Figure 1, taken from a December 2002 presentation by the Technical Advisory Council of the Federal Communications Commission, is an illustration describing radio wave usage. On the horizontal axis are different frequencies, denoted in megahertz (MHz). On the vertical axis are the recorded emission levels, measured in standard decibel units (dBm). While heavy usage (in radiated power) is not synonymous with economic value obtained from radio wave use, the pattern—with wide fluctuation in wireless activity—is highly suggestive.

**Figure 1. Spectrum Use Across Bands**

*Maximum Amplitudes*

<table>
<thead>
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<th>Frequency (MHz)</th>
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<td>100 MHz</td>
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<td>3000 MHz</td>
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In fact, the spectral graphic recalls the scenario described by Professor Heller in Russia. Brisk wireless business here and there, but with vacant bandwidth immediately adjacent to it. Were the intensity in the “heavy use” bands to extend to the “sparse” or “medium” use bands, social gains could be realized.\(^\text{28}\) Idle assets would become productive; new telecommunications services could be introduced.

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\(^\text{28}\) The FCC also produces charts showing the high variability of spectrum use in other dimensions beyond frequency space. These include time, geography, and power. In each case, these diagrams suggest that more opportunistic use of radio waves could produce valuable outputs without disturbing existing communications. It is important to note, however, that the actual efficiency of such uses depends on the value obtained, the expense incurred to create the new service, and the cost to other users. In some applications a band may be used in its highest valued use even if it appears relatively under-utilized, depending on the benefits accruing from bandwidth availability versus the benefits associated with alternative spectrum uses.
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services would be obtained. Instead, consumers appear to receive less service at higher prices. What accounts for this suboptimal allocation of resources?

Wireless networks would intensively use the barren frequency spaces if rights were defined such that markets could assign them to productive use. This is gleaned from the above FCC statement itself: the frequencies allocated to cellular telephone networks—liberally defined—are seen to host the most intense use. Section I.B, next, demonstrates how this liberal rights scheme for cellular telephones is socially valuable. The advantages of this type of regulation are then contrasted against two examples of less effective regulation: the regulation of the TV band (Section I.C) and the regulation of the MMDS Band (Section I.D).

B. The Social Value of Liberal Spectrum Property Rights

The property rights attached to wireless licenses in the United States have been notably extended in wireless telephony. For licenses issued to cellular, personal communications services (PCS), or specialized mobile radio (SMR) licenses, business operations are substantially left to the discretion of licensees. Operators are free to select technologies, services, and business models, deploying the frequency space allocated to their licenses as dictated by profit incentives. This market—summarized as commercial mobile radio services, or CMRS—utilizes about 170 MHz of bandwidth in the 800 MHz, 900 MHz, and 1.9 GHz bands.

I characterize the rights regime in this sector as EAFUS—exclusively-assigned, flexible-use spectrum rights. This corrects the FCC's designation of such rights as "exclusive use." In fact, the radio spectrum assigned to EAFUS (i.e., CMRS) licensees is intensively shared. Common access among millions of subscribers is organized by network operators which, with broad rights to control the use of specific frequencies, invest heavily to provide opportunities for consumers to communicate via wireless networks. This investment can be summarized in both physical capital—for instance, the creation of 174,368 cellular base stations—and financial capital—the expenditure of $156 billion in aggregate capital investment (book value through June 2004). The coordination effort entails much more, as the network carrier selects a menu of voice and data offerings, bringing together hundreds of equipment manufacturers and applications providers, while packaging and marketing services for the convenience of users. Currently, over 169 million wireless subscribers use these services, paying about $100 billion annually for over one trillion minutes of use.

29 SPTFR 2002, supra note 14, at 5.
31 Id.
Such intense sharing of radio waves could not take place at the price paid (about 10 cents per minute, on average, in the second quarter of 2003) were EAFUS rights not the regulatory model. The emergence of competition—with six national networks and several regional carriers offering service in 2004—has had a decided impact, as seen in the sharp price drop of wireless rates following entry by new PCS licensees in the mid 1990s. Consolidation of disparate local licenses, given the extremely atomistic licensing policy of the FCC, also reduced roaming charges and led to the introduction of popular “digital-one-rate” plans offering consumers buckets of local and long distance minutes at a flat rate. This entry included substantial irreversible investment in network infrastructure, and without exclusive rights to allocate the spectrum these networks were designed to use, these investments in competitive platforms would have been deterred.

The social value of the quasi-property rights regulatory structure in the CMRS bands can be estimated. Using historical price and quantity (minutes of use) data, consumer surplus has been inferred to be about $81 billion annually. This estimate is not based on a demand curve, in that the price-quantity pairs are observed over time, rather than at a single point in time. During the intervals, many other demand drivers are changing, including such

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32 First-half 2004 revenues equaled $49.3 billion, exceeding same-period 2003 revenues by over 19%. Id.
33 Extrapolating from minutes used in the first half of 2004, which exceeded 500 billion. Id. at 6.
34 MICHEL MORIN, ET AL., GLOBAL WIRELESS MATRIX 2Q03: QUARTERLY UPDATE ON GLOBAL WIRELESS INDUSTRY METRICS 26 tbl.14 (2003) (on file with author) (using revenue per minute for price per minute).
37 Id. at 193-99.
38 Not all regulatory restraints on the use of licensed spectrum diminish anticipated profits. In fact, many license restrictions can be seen as cartel enforcement devices that lessen competition between providers. In this case, anticipated profits rise due to license restrictions. This empirical result has actually been found in the wireless telephone market. HAZLETT, supra note 12. Scott Wallsten has recently produced evidence showing that legal restrictions on competition, even when they increase anticipated profits, reduce investment incentives. SCOTT J. WALLSTEN, PRIVATIZING MONOPOLIES IN DEVELOPING COUNTRIES: THE REAL EFFECTS OF EXCLUSIVITY PERIODS IN TELECOMMUNICATIONS (AEI-Brookings Joint Ctr. for Regulatory Studies, Related Publication 03-17, 2003), available at http://www.aei-brookings.org/admin/authorpdfs/page.php?id=282 (last visited Mar. 10, 2005).
40 Id. at 45.
factors as the price of handsets, the quality of cellphone calls, wireless network coverage, and the general popularity of mobile phone use. The assumption behind this estimate is that non-price demand determinants were operating to generally increase demand during the 1991-2003 period, which is easily defensible. A curve constructed from historical revenues and minutes of use then represents a lower bound estimate of demand for wireless minutes at each price, and integrating the area under the curve and above the current price of wireless minutes yields a lower bound estimate of consumer surplus for 2003 of approximately $81 billion. The capitalized social value of CMRS bandwidth then likely exceeds $1.6 trillion, a conservative calculation that excludes producers' surplus.

C. Excessive Rights Fragmentation in the TV Band

The value of EAFUS rights, and the intense investment and economic activity that occurs there, stands in stark contrast to bands in which rights are regulated under alternative models. I first examine the television band, before turning to the so-called MMDS band.

Some 402 MHz of prime bandwidth—67 channels at 6 MHz each—is allocated to over-the-air television broadcasting in each of 210 TV markets. This frequency space is more than twice the bandwidth allocated to wireless telephone service, and is generally of higher utility to network providers (being lower on the dial).

Of course, TV broadcasting also provides value. The economic question is the net change in social value from substituting alternative uses of the TV band frequencies. For simplicity, I assume the alternative service to be CMRS, both because CMRS networks demonstrate high demand for additional spectrum access, and because such networks (given their liberal license rights) are able to provide a wide array of wireless services to customers. Moreover, CMRS, which provides mobility using cellular network architecture, is well suited to the propagation characteristics of the TV band.

41 Id. at 44-45.
42 Id. at 4 app. 2, at 45.
43 This assumes a real social discount rate of 5%, which is a standard parameter used to estimate social costs and benefits. Robert W. Hahn, The Economic Analysis of Regulation: A Response to the Critics, 71 U. Chi. L. Rev. 1021 (2004). This is a conservative assumption here, given the high growth rate of consumers' surplus (which reduces the net discount rate in calculating present value).
45 Id. at 36.
46 Assuming a given alternative is conservative, biasing the analysis in favor of its current use. Other potential applications may have higher social value. They are excluded only because it is difficult to impossible to quantify the value of services not yet deployed.
47 Industry experts identify the lower frequencies, which the TV band occupies, as highly desirable for mobile voice or data applications. "Spectrum in the 300 MHz to 3000 MHz range is
One key aspect of market structure is that the programming aired by broadcast TV stations is distributed mostly via cable television and direct broadcast satellite; about 90% of homes use multi-channel video program distributors (MVPDs) to receive their television signals. It is useful to break "TV broadcasting" into two components: (a) broadcast TV content, meaning the programs TV stations and networks produce; and (b) broadcast TV distribution, the transmission system for delivering these video products to viewers. If this latter function is transferred entirely to cable and satellite TV systems, existing broadcast content will continue to be delivered to the same potential audience. The cost of making this delivery platform substitution then defines an upper bound on the value of the broadcast TV distribution system, by which I mean the transmission grid used by stations for over-the-air signals, and which includes 402 MHz of allocated radio spectrum.

Making this delivery substitution would involve shifting approximately ten million non-subscribing households to cable or satellite TV systems that carried local broadcast TV channels. According to FCC data, 97% of U.S. homes are passed by cable; roughly 100% are able to receive the signals of two national satellite TV providers. The incremental cost of an additional subscriber to cable systems (including installation of a digital set-top box), or to satellite TV systems (including installation of an outdoor dish), is under
Hence, to provide another ten million homes broadcast TV programs via MVPD distribution would entail aggregate outlays of less than $3 billion.\(^5\)

The social valuations associated with the TV band and the CMRS bands are striking. The former, encompassing 402 MHz, contributes less than $3 billion to national wealth in present value terms. The CMRS frequencies, allocated just 170 MHz, generate at least $1.6 trillion. These enormous disparities suggest that substantial social gains are available from reallocation of TV band spectrum.\(^6\) The regulators’ approach is that reallocation is taking place with the “digital TV transition.” This is not a regime shift, but a set of revisions within the existing regulatory structure. Officially initiated in 1987, the administrative plan to shift over-the-air TV broadcasting from analog to digital signal transmission has succeeded thus far only in blocking reallocation of TV band airwaves. In fact, alternative uses for the bandwidth was suggested by public safety users and cellular technology suppliers who petitioned the FCC in the mid-1980s for permission to access these largely idle airwaves.\(^7\)

There is now considerable interest in accelerating the TV Band reallocation, as pent-up demand for access to these valuable airwaves intensifies.\(^8\) The primary obstacle to unleashing this bandwidth is often

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50 HAZLETT, supra note 44, at 16.
51 It should be noted that all cable TV systems retransmit all local TV stations, see infra note 57 and accompanying text, while at least one satellite operator currently offers local signals in 130 television markets, covering over 90% of the country’s television households, DIRECTV, Local Channels Markets, at http://www.directv.com/DTVAPP/see/LocalChannels_markets.dsp (last visited Apr. 15, 2005).
52 The key assumption is that marginal valuations are also (in addition to the inframarginal valuations examined here) weighted heavily in favor of CMRS applications. Marketplace evidence strongly supports this assumption. For instance, cellular and PCS operators are willing to pay billions of dollars for licenses that allow them to access additional spectrum. One example is the 2004 “spectrum swap,” where wireless carrier Nextel was granted a new license allocated 10 MHz of spectrum (in the 1.9 GHz band), in a deal valued at $4.8 billion by the FCC. Brian Blackstone, Nextel Accepts FCC Spectrum Swap, WALL ST. J., Feb. 8, 2005, at D8; Reuters News, Nextel Accepts FCC Spectrum Swap Plan (Feb. 7, 2005), available at http://www.consensusplan.org/plg/template/consensus/21/3745 (last visited Mar. 21, 2005). In contrast, TV broadcasters are keenly interested in gaining “must-carry” rights to reach viewers via cable and satellite TV systems, see infra text accompanying note 57, but have no demonstrated interest in bidding for rights to expand over-the-air broadcasting. For a general analysis of the marginal value of spectrum used for wireless telecommunications, see HAZLETT & MUNOZ, supra note 39.
53 This story is well told in JOEL BRINKLEY, DEFINING VISION (1997).
54 The FCC is aware of the pressures:
Federal regulators are thinking anew when it comes to the digital-television transition. The Federal Communications Commission — feeling heat from Congress, which is under pressure from the spectrum-hungry wireless-phone industry — is trying to map a plan that would set a firm date for the return of broadcasters’ analog spectrum. The FCC’s Baedeker appears to be the city of Berlin. Last summer, the German capital became the globe’s first major city to shut down off-air analog TV in a flash-cut to all-digital broadcasting that came off without any documented displays of civil unrest.

According to government and industry sources, FCC chairman Michael Powell and Media Bureau chief Kenneth Ferree, learning from the Berlin example, are mulling a few options and bouncing them off congressional staff on Capitol Hill for a read on their political viability.

identified as broadcaster protectionism. In common parlance, the assertion is made that broadcasters will not part with their spectrum.

Sen. John McCain (R-AZ), chair of the Senate Commerce Committee (with oversight responsibility for the FCC), states it this way:

The transition to digital television has been a grave disappointment for American consumers and nothing short of a spectrum heist, for an indefinite period of time, by television broadcasters. As USA Today reported on May 1 [2002], "... At the current pace, broadcasters will be able to keep all of their spectrum, digital and analog, in perpetuity. That means a substantial chunk will remain locked up in broadcasters' hands, instead of being put to more valuable uses, such as for advanced cell phone services. Not only are those needed, the spectrum also could be sold for billions, aiding a deficit-laden U.S. Treasury."55

Similarly, former FCC Chairman William Kennard objected to the broadcasters' lack of commitment to the FCC's digital transition plan:

Federal Communications Commission (FCC) Chairman William Kennard last week called television broadcasters “spectrum squatters” that hoard “the most valuable resource of the Information Age.” ... The broadcasters can operate on both [analog and digital] channels until 2006 or until over-the-air DTV [digital television] serves 85% of the U.S. market. “Given the way that broadcasters are dragging their feet at the moment, we may not see that level of DTV penetration until 2025,” Kennard said.56

In fact, the tragedy of the anticommons is observed due to precisely the opposite state of affairs: because broadcasters do not enjoy property rights (or the ability to freely control use), they are unable to either deploy services that are demanded by consumers, or to 'cash out' by selling allocated bandwidth to alternative service providers who can do so more efficiently. In essence, the rights to provide a service of little value—TV broadcasting—is held by TV licensees, while rights to provide far more valuable services are held jointly by a large number of policy makers. The rights to provide new services are complementary with the rights held by broadcasters, as the spectrum allocated to the latter can be combined with the former to increase economic output. This puts broadcasters in a position similar to the overlapping rights holders in Moscow real estate, blocking productive enterprise with hold-up demands.

Ending the stalemate is difficult. First, policies that create economic incentives for broadcasters to cooperate tend to be strongly resisted by broadcasters (if this is done through penalties) or by the public (if this is done with rewards, often labeled “giveaways”). Second, broadcasters’ financial interests lead them not toward a generic property rights regime, which is a defensible policy alternative to the status quo, but to new claims of special

rights. That bundle may contain some elements of liberalization (e.g., the right to reallocate digital TV spectrum for non-TV services) but will also retain protections favoring broadcasters against competitors. The most obvious are "must-carry" rights. These grant TV licensees priority placement on cable and satellite TV systems, effectively vesting broadcast TV licensees in the use of their rivals' radio spectrum. Given must-carry, broadcast TV licensees also have a keen interest in the continuation of regulatory entry barriers in broadcast TV markets. Without such, the value of carriage rights would be dissipated by competition.

Until a bargain to reallocate TV band spectrum is struck, TV licensees are left with a severely truncated set of rights. This preserves, however, the option they exercise to veto alternative uses of TV band spectrum. Rather than search out more valuable uses of radio spectrum, broadcasters devote their efforts to blocking reallocations that distribute rents in a manner that is disagreeable. The unproductive activity follows from the fact that the TV Band is not "their spectrum."

The transactions costs of arranging beneficial reallocation are high. They include decades-long delays during which policy makers attempt to craft a delicate political bargain, inducing incumbent TV broadcasters to withhold their veto without being seen to engage in "giveaways." The anticommons tragedy occurs precisely because this stand-off leaves rights distributed in a manner in which the valuable TV band airwaves cannot be used productively.

D. Excessive Rights Fragmentation in the MMDS Band

Just above the PCS band (1.9 GHz) and the unlicensed ISM band (2.4 GHz) is the MMDS/ITFS band (2.5-2.7 GHz) (the acronyms stand for Multichannel Multipoint Distribution System and Instructional Television Fixed Service). The band was allocated 190 MHz of spectrum, and is

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58 How broadcasters have developed such power to control FCC rules is due to a combination of incumbency advantages generic to regulated markets, and special considerations attendant to the fact that broadcasters specialize in the production of "publicity," the key input into legislators' support functions. See Thomas W. Hazlett, Assigning Property Rights to Radio Spectrum Users: Why Did FCC License Auctions Take 67 Years?, 41 J.L. & ECON. 529 (1998).
59 The FCC has recently switched acronyms. MMDS is referenced as BRS, for Broadband Radio Service. ITFS is EBS, for Educational Broadband Service. In the Matter of Amendment of Parts 1, 21, 73, 74 and 101 of the Commission's Rules to Facilitate the Provision of Fixed and Mobile Broadband Access, Educational and Other Advanced Services in the 2150-2162 and 2500-2690 MHz Bands, Part I of the Commission's Rules – Further Competitive Bidding Procedures, Amendment of Parts 21 and 74 to Enable Multipoint Distribution Service and the Instructional Television Fixed Service Amendment of Parts 21 and 74 to Engage in Fixed Two-Way Transmissions, Amendment of Parts 21 and 74 of the Commission's Rules with Regard to Licensing in the Multipoint Distribution Service and in the Instructional Television Fixed Service for the Gulf of Mexico, Promoting Efficient Use of Spectrum Through Elimination of Barriers to the Development of Secondary Markets, WT Docket No. 03-66, RM-10586, WT Docket No. 03-67, MM Docket No. 97-217, WT Docket No. 02-68, RM-9718, WT Docket No. 00-230 (released July 29, 2004), 19 F.C.C.R. 14,165, at 14,169 para. 6
considered valuable for fixed or mobile wireless service offering voice telephony or high-speed data. Yet rights to use this radio resource are distributed in a manner that has squandered these valuable opportunities.

Confirmation is provided by evidence from secondary markets. License values in the CMRS market are visible thanks to market trades of PCS and cellular assets. In one recent transaction, FCC regulators were prompted to establish a valuation for a PCS license allocated 10 MHz of unencumbered nationwide spectrum in the 1.9 GHz band. This valuation was set, in 2004, at $4.8 billion, or about $1.71 per MHz per person, the standard metric used to compare such licenses (and presented as “price/MHz/pop”).

In contrast, various wireless operators are attempting to aggregate MMDS licenses in order to provide wireless broadband services. Nextel purchased MMDS licenses held by WorldCom (which disposed of the licenses in its bankruptcy proceeding in 2004) for $144 million. While it is unclear what coverage these licenses convey or the bandwidth allocated to them, it is clear

(2004) (report & order & further notice of proposed rulemaking), available at http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-04-135A1.pdf (last visited Mar. 25, 2005) [hereinafter FCC July 2004 Order]. The traditional acronyms are used in this paper. The wireless applications provided in this band consist of three main types. First, educational institutions using ITFS licenses provide video feeds to various locations in a city—typically school campuses—of instructional programming. Id. at para. 10. Second, MMDS licenses have delivered subscription television services to households (wireless cable), beginning in 1974 and adding channels over time. Id. at para. 11-12. As of September 2004, MMDS subscribers numbered 100,000 and account for only 0.10% of the MVPD market. NAT'L CABLE & TELECOMM. ASS'N, 2004 YEAR-END INDUSTRY OVERVIEW 20 chart 10 (2004), available at http://www.neta.com/pdf_files/NCTAYearEndOverview04.pdf (last visited Mar. 25, 2005). Since 1998, FCC rules have also permitted two-way digital services, leading to a third application: wireless broadband. FCC July 2004 Order, supra, at para. 14. “First generation” attempts by Sprint (among other providers) were unsuccessful. Wireless Communications Ass'n, Int'l, et al., A Proposal for Revising the MDS and ITFS Regulatory Regime 3-4 (Oct. 7 2002) (white paper submitted to Mr. Thomas J. Sugrue, Chief, Wireless Telecommunications Bureau, Federal Communications Commission on Oct. 7, 2002) (on file with author) [hereinafter WCA 2002]. “Second generation” technologies are now being deployed, and may fare better. These systems are predominantly non-line of sight (NLOS), meaning that they eliminate the need for professionally installed roof-top receivers by allowing indoor reception via small antennas attached to notebook or desk-top PCs; the newer applications are often identified as “WiMax.” See id. at 6-7; The WiMax Procession, DAILY WIRELESS (Mar. 15, 2005), http://dailywireless.org/modules.php?name=News&new_topic=29 (last visited Mar. 21, 2005). For brevity, the spectrum allocated to ITFS and MMDS is referred to simply as the “MMDS Band” in the text.


that they were sold for a small fraction of the value of PCS licenses. One wireless equipment executive observed: "The spectrum Nextel got was 1/200 the cost of mobile spectrum. A lot of that has to do with how messy the process of being able to provide services in the spectrum [prior to upcoming reallocation] has been . . . ."

More systematic evidence on the value of MMDS licenses was compiled for 2001 sales by industry consulting firm BIA Financial. These data reveal that, for the typical U.S. market, MMDS licenses were valued at about $0.048/MHz/pop, or just 3% as much as PCS licenses.

A petition to the FCC in late 2002 requested that a plan to reconfigure the rights issued in the MMDS be instituted. The plan, reached by consensus through negotiations with various license holders in the band, seeks to eliminate various inefficiencies in the assignment of rights. Each stems from the fact that this band was originally allocated to broadcast services, and licenses permit the operation of a one-way transmitter in a fixed location to emit at high power levels. The type of service licensed has never been much demanded, and the MMDS rules were relaxed in 1998 to allow licensees to use the allocated frequencies for two-way broadband, which presumably is in demand (as seen in the rapid growth of digital subscriber lines and cable modems).

The transition to new services under the old spectrum rules creates several transactional difficulties, however. First, broadband systems want to re-use frequencies. The architecture, widely applied in mobile voice networks (CMRS), allows operators to create cells wherein a base station transmits to, and receives signals from, mobile radios (i.e., cellphones). By emitting just enough power to communicate with the nearest base station, the system is designed to accommodate connections (phone calls or data links) using the bandwidth allocated within each cell, and then to essentially reuse the same frequency space in other cells. Unfortunately, MMDS rules were adopted for a broadcasting model, which envisions one high-powered transmission of signals to receivers. Because everyone gets the same (broadcast) content, which flows just one way, cellularization is not accommodated.

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64 BIA Financial’s estimate of the average 2001 price/household/channel was $0.75. Camilla Jensen, ITFS in the Era of Mobility, Presentation to the NIA Conference, Tempe, Arizona (Feb. 2002) (on file with author). My calculation assumes 2.6 persons per household, the mean value derived from U.S. CENSUS BUREAU, CENSUS 2000 BRIEF C2KBR/01-8, HOUSEHOLDS AND FAMILIES 2000 1 (2001), available at http://www.census.gov/prod/2001pubs/c2kbr01-8.pdf (last visited Mar. 11, 2005). With the average household consisting of 2.6 persons, and each MMDS channel consisting of 6 MHz, price/MHz/pop = $0.75/2.6/6 = $0.048.

65 WCA 2002, supra note 59. The following four paragraphs draw on this source.
Hence, FCC rules have mandated that each MMDS transmitter be licensed, imposing lengthy and costly administrative overhead on cellular networks. In essence, the subdivision of spectrum space is heavily taxed.

Second, transmitter separation rules to limit interference between TV stations are inappropriate for broadband, where receivers are better able to decipher transmissions. Current rules leave large areas where broadband transmitters (either base stations or client radios) could not transmit because such emissions—while inconsequential to other broadband systems—would theoretically disturb broadcast signals—which may not exist but which regulations still protect. This fragments spectrum rights and imposes very large transactional costs (the expense of acquiring new FCC rules) on those attempting to reassemble them for productive use.

Third, many channels assigned to instructional broadcasters are "interleaved" with channels assigned to microwave users. See the MMDS band in Figure 2. This was originally done to limit interference between users, but it now—given new uses causing different spillovers between channels—"hampers the ability of individual MDS and ITFS licensees to deploy broadband services by giving adjacent channel licensees a 'veto power' over any proposed offering." The interleaving of ITFS and MMDS channels graphically illustrates transactional difficulties by forcing a relatively large number of spectrum sharing (or "interference") agreements to be struck. Transactions are also hampered by the fact that agreements often involve multiple licensees and that adjacent channels in both ITFS and MMDS have often been allocated to licenses awarded to different parties.

### Figure 2. The MMDS Band

<table>
<thead>
<tr>
<th>Channel Assignment</th>
<th>Frequency Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>EBS</td>
<td>2500 MHz</td>
</tr>
<tr>
<td>BRS</td>
<td>2690 MHz</td>
</tr>
</tbody>
</table>


Wireless licenses have been issued in the MMDS band since 1963. Recent deregulatory actions have expanded the scope of many of the licenses issued. But the extremely incomplete nature of the rights, combined with their

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66 Id. at 10.
67 This means, for example, that the seemingly contiguous channel assignments in ITFS are, in fact, subject to substantial fragmentation.
wide dispersal, has rendered the band virtually worthless. In July 2004, the FCC largely agreed with this assessment, when it moved towards initiating the rebanding plan requested by the MMDS and ITFS licensees. It prompted FCC Chairman Michael Powell to issue this statement:

We are witnessing the dawn of a new era for wireless broadband. Today’s decision does away with heavy-handed rules that have governed the MDS/ITFS band ("2.5 GHz band") for far too long. Freed from regulatory shackles, educational institutions will now have the flexibility to utilize their spectrum in the way most advantageous to the students and the public they serve.

The magnitude of today’s ruling is apparent when one considers that this band is double the spectrum that sparked the WiFi explosion at 2.4 GHz and equivalent to the entire spectrum devoted to terrestrial mobile, wireless services.

II. Unlicensed Spectrum’s Dual Tragedies

"The Commission’s rules for unlicensed transmitters have been a tremendous success. . . . The success of our unlicensed device rules . . . shows that there could be significant benefits to the economy, businesses and the general public in making additional spectrum available for unlicensed transmitters." 69

Since the issuance of its Spectrum Policy Task Force Report in November 2002, the FCC has moved unlicensed spectrum use to the top of its regulatory agenda. In the intervening months, proposals to allocate more unlicensed spectrum have been advanced by the Commission for the television band 70 and the 3650-3700 MHz band. 71 The Interference Temperature proceeding proposes to allow unlicensed use of low-power underlays in licensed bands, 72 a proposal

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68 FCC July 2004 Order, supra note 59.
71 Id. at 25,632 para. 1, 25,637-38 para. 14.
73 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, ET Docket No. 03-237 (released Nov. 28, 2003), 18 F.C.C.R. 25,309
similar to that advanced in the cognitive radio notice. In late 2003, an additional 255 MHz of spectrum was allocated for unlicensed use in the 5 GHz band. This follows the 1998 U-NII allocation, under which 300 MHz in the 5 GHz band was allocated for unlicensed use.

Table 1. Flexible-use Licensed and Unlicensed Bands
(estimated monetary values for 2003)

<table>
<thead>
<tr>
<th>Band</th>
<th>MHz</th>
<th>Type</th>
<th>Services</th>
<th>Est. Service</th>
<th>Est. Equip.</th>
<th>Est. Network</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Rev.</td>
<td>Rev.</td>
<td>Capex</td>
</tr>
<tr>
<td>1.9 GHz</td>
<td>20</td>
<td>UN</td>
<td>Voice, data, UPCS handsets</td>
<td>$0</td>
<td>$0.04</td>
<td>$0.02</td>
</tr>
<tr>
<td>900 MHz</td>
<td>26</td>
<td>UN</td>
<td>Remotes, listening devices, cordless</td>
<td>$0.088</td>
<td>$3.81</td>
<td>$2.264</td>
</tr>
<tr>
<td>2.4 GHz</td>
<td>83.5</td>
<td>L</td>
<td>phones, wireless LANs, WiFi,</td>
<td>billion</td>
<td>billion</td>
<td>billion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>microwave ovens, ISM equipment,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>local positioning systems</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 GHz</td>
<td>555</td>
<td>UN</td>
<td>WiFi, HiperLAN, HiSWAN, IEEE 802.16</td>
<td>$0.014</td>
<td>$0.197</td>
<td>$0.017</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td></td>
<td>devices, cordless phones, amateur</td>
<td>billion</td>
<td>billion</td>
<td>billion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>radio, field disturbance sensors,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>aviation radar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>800 MHz</td>
<td>189</td>
<td>LIC</td>
<td>Mobile phones, data</td>
<td>$88</td>
<td>$13</td>
<td>$21</td>
</tr>
<tr>
<td>1.9 GHz</td>
<td></td>
<td></td>
<td></td>
<td>billion</td>
<td>billion</td>
<td>billion</td>
</tr>
</tbody>
</table>

Source: Adapted from Thomas W. Hazlett & Matthew L. Spitzer, Advanced Wireless Technologies and Public Policy 27 tbl.5 (Dec. 12, 2004) (working paper, on file with author).


77 This bandwidth, 189 MHz, is the maximum amount allocated to CMRS licenses. Thomas W. Hazlett & Matthew L. Spitzer, Advanced Wireless Technologies and Public Policy 26-27 (Dec. 12, 2004) (working paper, on file with author). In fact, much of this bandwidth has been unused due to litigation involving PCS C block licenses. KWEREL & WILLIAMS 2002, supra note 13, at 9. This is why the 170 MHz CMRS allocation is used in this article to describe the frequency space actually utilized by operators.
This relatively frenetic regulatory activity contrasts with a de facto freeze on licensed allocations. The PCS rule making, which officially began in 1990, allocated 120 MHz for liberally regulated licensed use (and 20 MHz for unlicensed use). PCS licenses were assigned in auctions held in 1994-1996. Since that time, there have been no license assignments for CMRS (or EAFUS) rights in comparable spectrum. 78

In steering toward unlicensed allocations, the Commission’s logic is simply stated above. Unlicensed devices are observed to be popular in the marketplace; it is therefore in the public’s interest to allocate more frequency space for their use. In this section, I examine this reasoning in light of the potential for common interest tragedies. Part II.A extends the scholarship on common pool resources, which helps focus attention on the mechanisms used to coordinate spectrum use. Generally, whenever economic scarcity obtains, access is limited either by rules prescribing how a resource may be utilized, or by assigning exclusive rights to decentralized parties (who are then free to enact their own use rules). In Part II.B, this paradigm is applied to radio spectrum, where it helps to explain the costs and benefits of alternative forms of regulation. The power limits (governance) used to coordinate users of unlicensed devices, for instance, help separate resource users and so mitigate conflicts, but the constraints imposed by such limits make certain valuable wireless networks much more expensive. Finally, Part II.C reviews a number of common interest tragedies that can occur simultaneously, including those related to the provision of efficient regulatory policy, which is itself a public good.

A. Governance v. Exclusion

Scholarship on common ownership systems indicates that property rights need not be exclusively assigned for an efficient market outcome to obtain. Various rules, customs, or “protocols” may, depending on circumstances, be as effective in rationing the use of scarce resources as the price system assigning exclusive rights. The relevant issues involve the efficiency of group decision-

78 A very recent FCC decision to allow a satellite telephone operator to provide terrestrial phone service using the same allocated frequencies (used for satellite links) may end this drought. In the Matter of Mobile Satellite Ventures Subsidiary LLC, Application for Minor Modification of Space Station License for AMSC-1, Minor Amendment to Application for Authority to Launch and Operate a Next-Generation Replacement MSS Satellite, Application for Minor Modification of Blanket License for Authority To Operate Mobile Earth Terminals with MSAT-1, File No. SAT-MOD-20031118-00332, File No. SAT-AMD-20031118-00332, File No. SES-MOD-20031118-01879, File No. SAT-MOD-20031118-00333 (released Nov. 8, 2004), 19 F.C.C.R. 22,144 (2004) (order & authorization). It is not clear, however, that the new terrestrial transmission rights, awarded as ancillary to primary satellite rights, id., will enable economical provision of valuable services.

Useful analysis of the trade-offs between alternative approaches for rationing scarce goods is found in the "exclusion-governance" dichotomy elucidated by Henry Smith.\footnote{Henry E. Smith, Exclusion Versus Governance: Two Strategies for Delineating Property Rights, 31 J. Legal Stud. S453 (2002).} In this framework, resource-use conflicts are dealt with in two distinct ways. On one side of the continuum, access to the resource is exclusionary; dissipation (including the tragedy of the commons) is avoided by ownership—exclusion. At the other end, uses are regulated—governance.

The real world mixes these limiting devices in various proportions. Choice of rationing instrument focuses on the value of the underlying resource, as well as the cost of measuring resource use. This framework helps explain the licensed versus unlicensed regulatory choice in radio spectrum. Unlicensed bandwidth is not a "commons" in the sense of common ownership.\footnote{Despite its common designation as such. See, e.g., SPTFR 2002, supra note 14.} Rather, the government allocates bandwidth without private ownership rights, and then levies restrictions on equipment and usage. Power levels, protocols, and business models\footnote{For instance, in 2002 the United Kingdom had prohibitions against commercial services being provided using unlicensed bandwidth, thus rendering fee-based hotspot providers illegal. Andy Dorman, Europe Warms to Hotspots, Network Magazine (June 5, 2002), http://www.networkmagazine.com/article/NMG20020603S0001 (last visited Mar. 25, 2005). This was a device to limit spectrum crowding.} are adjusted by regulators to mitigate conflicts. The aim is to separate users by limiting emissions, helping to avoid congestion.

Where users are regulated such that interfering with their neighbors’ (low powered, localized) use of spectrum space is relatively difficult, but certain valuable applications can still be economically supplied, production may be organized within the wireless device market such that valuable services are produced. Moreover, over-use may be avoided. That is, users of wireless devices—say, cordless phones, garage door openers, or WiFi systems (cordless PC connections)—purchase equipment that exploits the opportunities afforded under rules for unlicensed use. Conflicts are limited by governance.

Some argue that competition among equipment vendors will itself produce an efficient outcome in an unlicensed spectrum regime. But bandwidth lacking exclusivity or governance will predictably degenerate into suboptimal deployment when scarcity conditions apply. These conditions obtain in many situations, including those involving the largest numbers of consumers in the most desirable frequencies. To avoid dissipation of valuable resources, unlicensed bands are regulated.
Spectrum Tragedies

Such regulation leaves open the possibility of market failure. This commonly occurs when actions are taken that imply spillovers, but where decision makers have no economic incentive to account for these external costs or benefits. Spectrum use entails standard common pool resource allocation issues, in that the activities of one can spillover to impact the activities of another. These effects are taken into account when exclusive rights are exercised. EAFUS licensees, for instance, attempt to use technologies that reduce the bandwidth needed to provide a given communications link, because that creates more capacity for other communications and value from these additional services can be captured by the network operator. In an unlicensed situation, the radio spectrum user may use advanced (and more costly) systems to conserve spectrum capacity, but much of the benefit will accrue to others. This is why unlicensed usage is regulated by power limits, protocols, and occasional group activity to restrain over-consumption.

Short-range applications are relatively compatible with frequency sharing on an unlicensed basis, so long as users spread out geographically. Ironically, this implies that unlicensed usage works to the degree that users do not share the same physical space; sharing then becomes too complicated and conflicts between users too numerous. With relatively simple rules such as power limits, some localized applications can be supplied without extensive sharing by using low power wireless devices. The effectiveness of such radios derives in part from the fact that other wireless users are limited in the power they may use in these same frequencies. In practical terms, this excludes users who are more than a few meters away from offering interference. This form of governance then yields each user some level of exclusivity in the use of airwaves.

83 To the extent that the regulatory rules themselves create inefficiencies, it would be proper to attribute the resulting social losses to non-market failure. Charles Wolf, Jr., A Theory of Nonmarket Failure: Framework for Implementation Analysis, 22 J.L. & ECON. 107, 128 (1979).

84 A recent conference held at George Washington University, which provided unlicensed WiFi connectivity for conference participants, distributed the following plea:

Note that this is a 10 meg point that will be shared by many people, so please use it in moderation and avoid huge downloads or other bandwidth-hogging activity. Also note that you may run into some interference with the campus networks and the general wireless haze in the DC area.

Flyer, Future of Music Coalition, Fourth Annual Future of Music Policy Summit, We have Wireless Internet Access Inside Lisner, Washington, D.C. (May 2-3, 2004) (on file with author). A recent newspaper article relayed a story about "one Florida suburb where so many signals jammed each other that residents formed an 'ad hoc neighborhood spectrum allocation committee' of WiFi users." Mike Musgrove, Here, There, WiFi Anywhere: Wireless Web's Spread Is Crossing Our Signals, WASH. POST, Apr. 25, 2004, at F1. When hotspots become over-crowded, access slows or stops, the product of insufficient network coordination. This has been known to happen at trade shows run by tech experts. "Wireless snafus at TechEd in Barcelona and CeBIT in Hanover have been well-documented. Both incidents had the same simple cause: an expert network installer failed to produce a working network because there were too many wireless units." Guy Kewney, Breaking Wi-Fi Gridlock, EWEBK (Sept. 10, 2003), http://www.eweek.com/printarticle2/0,2533,a=61379,00.asp (last visited Mar. 3, 2005); Musgrove, supra (noting CeBIT problems); see also Nick Hunn, CeBIT Over-Does the WiFi - It Falls Over!, NEWSWIRELESS.NET (Mar. 14, 2003), at http://www.newswireless.net/index.cfm/article/1143 (last visited Mar. 26, 2005) (describing first-hand experiences with WiFi problems at CeBIT).
Rights to real property make a substantial contribution to the process. Because power limits separate users, owners of homes or enterprises exercise effective control over local airwaves. These actors may then allocate local bandwidth to rationalize the different applications they use. In particular, they can rearrange conflicting devices, using them at different times or by moving them to different unlicensed frequencies (say, 900 MHz for the cordless phone, 2.4 GHz for the WiFi system). Thus, exclusivity coordinates local usage: “Contrary to claims that the success of the FCC’s unlicensed regime in general and WLANs in particular, are the result and proof of a successful ‘commons’, it is local property owners exercising their de facto rights that have prevented a ‘Tragedy of the Commons’.”

WiFi hotspots can be built and maintained as a nationwide chain—such as T-Mobile’s Starbucks network—to create valuable wireless services. Access is “open” in the sense that unlicensed spectrum is used by the personal computers connecting to access points. But access is closed in two important respects. First, use of a commercial hot-spot service is restricted to subscribers who pay for the service. Second, high-power, long-range applications are excluded from using unlicensed frequencies, allowing each Starbucks to effectively control “its” airspace such that rival hotspots tend not to create congestion. This result does not always obtain; conflicts with nearby hotspots, or other unlicensed traffic, occur. Yet local airwave control has been sufficient to encourage the creation of thousands of hotspots nationwide.

But the policy mechanism that allows property owners to use local airwaves comes at a steep price. Unlicensed rules, particularly power limits, make investment in wireless networks exceedingly expensive for many applications. T-Mobile, to extend the example, maintains an infrastructure utilizing an average of 30 MHz of radio spectrum—much less than the 83.5 MHz available at 2.4 GHz (or 300 MHz in the 5 GHz band) for WiFi use—to serve over 17 million subscribers. In 2003, T-Mobile USA (owned by Deutsche Telekom) invested some $1.7 billion in capital infrastructure.

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contrast, T-Mobile hotspot investment is relatively trivial, as is the measurable economic activity that occurs there.

Given the flexibility to use higher or lower power levels and other efficiencies gained from excludable spectrum rights, financial markets are observed sinking relatively large quantities of capital in wireless infrastructure, generating valuable opportunities for customers. The value derived from short range applications via unlicensed spectrum comes courtesy of use restrictions that deter efficient use in wider area applications. When an ambitious effort is made to launch a nationwide network of public hotspots, as when Cometa (backed by Intel, IBM, and AT&T) announced in December 2002 that it would create a chain of 20,000 Wi-Fi access points around the U.S., the effort is hampered by the very power limits that make local area Wi-Fi networks possible in homes and offices. Cometa gave up its plan, folding in mid-2004 after constructing only about 200 hotspots.

To overcome such organizational problems, exclusively-assigned rights are crucial from the consumer's perspective. Under an unlicensed regime, a tragedy of the commons would be anticipated if government use controls were set too lightly, and a tragedy of the anticommons (underuse) would be anticipated if use controls are too restrictive. Importantly, the rules do not generally allow for the creation of wide area networks even in circumstances where consumers are willing to outbid all other users for the resources used, including the spectrum.

Abstracting from how one defines "success" (which cannot be correctly done without considering the opportunity cost of spectrum), the observed popularity of unlicensed devices for localized applications does not imply that additional spectrum would be efficiently used if allocated for unlicensed use, or that such a regulatory model should be used to encourage wide area broadband

90 A public hotspot can be constructed for about $1500. JEFF BELK, ADVENTURES IN THE PUBLIC HOTSPOT Wi-FI WORLD 13 (2003), available at http://www.qualcomm.com/enterprise/pdf/Adventures_in_the_Wi-Fi_Public_Hotspot--FINAL.pdf (last visited Mar. 5, 2005). This implies total infrastructure investment of around $8 million by perhaps the leading public hotspot network provider in the United States.

91 "In the U.S., In-Stat estimates that [this year] Wi-Fi providers will take in about $28 million – roughly as much as Verizon Wireless Inc., the nation's largest cellphone company, generates in 12 hours." Scott Thurm et al., Chill Hits Wi-Fi 'Hot Spots', WALL ST. J., Mar. 18, 2004, at B1.

92 In an environment where the network operator can control spectrum access, higher power levels can generally be used (extending geographic coverage of given transmitters). In addition, lower power levels can be utilized because the network operator, with control over frequency space, rationally coordinates usage, internalizes gains from reducing emissions for one user so as to create more communications capacity for others.


networks. Value is determined at the margin, and gains must be net of opportunity costs, which include the option of using the same (spectrum) resources organized under alternative (EAFUS) rules.

B. Coordinating Spectrum Use

Even with sharp power limits, some wireless technologies send signals that permit electronic communications over several miles, depending on the nature of the information relayed and the quality of the transmission and receiving equipment. Many rural wireless ISPs (WISPs) offer service—more than 2400 by one count. These broadband providers are reported to serve 200,000 households.

Unlicensed bands are relatively popular when providing two types of broadband access: (1) in homes, offices, or campuses (providing wireless short-range connections to high-speed networks); and (2) via rural broadband networks. These circumstances feature fewer spectrum conflicts; reduced scarcity tends to favor unlicensed usage. Alternatively, conflicts are more of a problem when using unlicensed airwaves to deliver wide area services to metropolitan customers. In densely populated areas, the provision of wireless service is much more likely to need coordination and therefore less likely to be worth the investment by carriers and their subscribers. Of the ten largest WISPs (by subscriber count) in 2004, none were located in major metropolitan markets.

The coordination provided by power limits tends to break down when operators overcome those limits to send signals greater distances. When airwave use crosses over the real property of many disparate parties, coordination becomes relatively important and negotiations become exponentially more difficult. This introduces the standard tragedy of the commons, experienced by many WISPs using unlicensed spectrum. In petitions filed with the Federal Communications Commission, such operators complain that interference with other unlicensed users seriously degrades the service received by their customers. One writes:

I own and operate a WISP (Wireless Internet Service Provider) in rural Southern Illinois. I provide services over the network I have built there that exceed the quality and varied uses seen in any other broadband based networks. ... This is not just coffee shop WiFi we are discussing . . . .

This type of highly engrained use of this technology in small towns and metro areas is not unique to Mt. Vernon, IL. These services are part of the infrastructure of our communities now on a worldwide scale. The aggressive adoption of these bands has come with little protections to WISPs and their

96 Id.
Spectrum Tragedies

high profile customers and is in danger of creating a disastrous implosion if nothing is done to remedy the impending interference hazards on the horizon. WISPs have no rights to the spectrum they use...

I want to suggest a policy to help solve these issues and provide unlicensed use of this band simultaneously. I propose a new policy called the "WISP Homestead Policy"... Homestead status would be given to WISPs who register with the FCC and provide documentation proving active use of ITFS frequencies within a given market service area. ... There would be no enforcement of license rights unless a homestead operator proves they have a claim to spectrum and that they are receiving interference from other sources.

This view is echoed in numerous other FCC filings by those attempting to use unlicensed frequencies for "last mile" broadband. Here, for example, are comments from Jeff Phillips of Rural Ramp:

I would like to encourage the FCC to reallocate some spectrum for exclusive use of internet service providers or other deployers of outdoor fixed wireless broadband data networks.

Currently numerous companies, mine included, are working to deploy high-speed internet service in areas it does not yet exist by using off the shelf wi-fi equipment because licenses and licensed equipment is much too expensive in many rural markets. A problem that we run into is that the 2.4 GHz and other ISM bands are jammed with all sorts of off the shelf consumer products, like cordless phones, security cameras, etc. Many of our customers would like to have their own home Wi-Fi Lan, and we have to ensure that their signals do not interfere with the one they are using on their roof to connect to our network. It is quite a bit of a pain to deal with at times.

I feel that the vast majority of wireless ISPs are more than willing to cooperate with each other to ensure that their network deployments do not cause signal interference with each other....

What we need is a small chunk of spectrum that any ISP or other outdoor network deployer can freely use without worry of interference by completely irrelevant devices. I would suggest charging a very minimal (say $100/year) registration fee for ISPs to identify themselves and the general area or community that they intend to use the spectrum in. This way when one goes to deploy a fixed wireless data network, we would not worry about interference from everybody and their brother and could get a very simple list of other organizations using the spectrum in our area, so that we can contact them and work out arrangements to ensure that our signals do not cause problems with each others networks. I would strongly discourage the FCC from allowing consumer products to use these frequencies, as they already have several different ISM bands to use (900 Mhz, 2.4 GHz, etc.).]


Excerpts from other FCC Comments submitted by WISPs are displayed in Table 2.1

<table>
<thead>
<tr>
<th>WISP Name</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliable Internet Services</td>
<td>I recently heard that the FCC was looking at adding more spectrum to the 2.4 band. This would be great for us as we could use it, with all of the 2.4 phones, home users having wireless networks, and other wireless isp's. It is hard to find channels that are not crowded.</td>
</tr>
<tr>
<td>John Buwa, Michiana Wireless</td>
<td>We are a small privately owned wireless internet service provider and would like to see more unlicensed spectrum in the MMDS/ITFS band that is available for our use. Something that is reserved for our industry would be nice to where a consumer could not knock our service out by something they can by [sic] at the store be it a [sic] access point or phone or camera or whatever rf device they use.</td>
</tr>
<tr>
<td>Accel Net, Inc.</td>
<td>We also would be in favor of adding some teeth to the ISM rules to keep operators from causing frivolous interference on sites that are being used for mission critical applications. We also need to get the amateur users off of this band as well.</td>
</tr>
<tr>
<td>Tim Steele</td>
<td>I would simply like to voice my desire to see more unlicensed spectrum in the MMDS/ITFS band. We (and other WISPs) are utilizing this resource to provide needed services to underserved areas as well as highly populated ones. Having this extra spectrum space will allow competition to thrive by allowing more space in which competitors can operate without interference.</td>
</tr>
<tr>
<td>Kevin Sullivan</td>
<td>We are currently using 5800, 2400 and 900 MHz [sic] to distribute high speed internet access to the rural community that we are located in. The addition of the 2.5 Ghz [sic] band, or a portion of it, would greatly help us provide reliable access, as well as let us expand existing tower sites to a larger customer base.</td>
</tr>
</tbody>
</table>

100 Many wireless experts have concluded that some form of exclusive rights will be needed to police "unlicensed" spectrum use:
What is almost certainly going to have to happen is a congestion charge. We'll have to evolve social mores to say who will provide the access point for an area, and what rights the rest of us have. We'll have agreements about turning off clients that aren't being used. We'll have a shift from private wireless transport to public infrastructures.

Kewney, supra note 84. Mike Chartier, of Intel, writes that he "advocates the establishment of local spectrum sovereignty, where the right to use some frequencies, and freedom from interference in using them, is attached to the property where they are used." Chartier, supra note 85, at 29.

101 Comments filed with the FCC can be searched on the agency's Electronic Comment Filing System, at www.fcc.gov/cgb/ecfs. This table consists of comments filed pursuant to Amendment of the Commission's Rules To Facilitate the Use of the Universal Licensing System in the 2150-2162 and 2500-2690 MHz Bands, WT 03-66.


One might ask: why can't equipment vendors compete to provide systems that relieve congestion experienced by unlicensed users? They do offer solutions, but they are geared towards letting the buyer communicate more effectively rather than economizing on spectrum space that could be used by others. When cooperation is relatively important, as in a wide area application that works most efficiently when considerably capital infrastructure is sunk, this market mechanism tends to work relatively poorly. Here the typical wireless customer demands an organized approach that is difficult to arrange without exclusively assigned spectrum rights.

Something akin to Ronald Coase's "nature of the firm" analysis is applicable.\(^7\) For some wireless applications, users find that they can effectively integrate into the spectrum coordination function (self-provisioning). They can buy the help they need embedded in the equipment they purchase, possibly aided by an enterprise-level "tech support" department or consulting services purchased on a stand-alone basis in the market.\(^8\) In other wireless endeavors, however, users find it efficient to purchase spectrum coordination services from an agent who organizes thousands or millions of subscribers into a network. This not only reduces conflicts given an existing communications infrastructure, it offers secure airspace encouraging the creation of irreversible investments. The enormous capital sunk in wireless networks operated on exclusively-assigned spectrum offers consumers services that are not economically viable under the governance model.

The very technologies that may encourage an individual service provider to provide wide area network service using unlicensed spectrum simultaneously create conflicts by encouraging others (individuals and networks) to attempt the same. This produces a moving target for interference control efforts. It also reveals why unlicensed applications tend to display relative success in those situations where user conflicts are less intense.

C. Multiple Allocation Tragedies

Administrative allocation of licensed radio spectrum has led to severe inefficiencies. This central planning approach—"Gosplan"—has few defenders.

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107 Coase, supra note 79. Coase inquired as to how firms decided to organize, with the key question involving choices between integration (producing within the firm) and the use of external (non-owned) factors. In producing an automobile, for instance, General Motors may make car bodies or purchase them from an outside vendor such as Fisher Body. Coase outlined a general analysis wherein the company sought to maximize returns by selecting, in each case, the most efficient solution. This depended on various economies of production, and the cost of using the market. See also Steven N.S. Cheung, The Contractual Nature of the Firm, 26 J.L. & Econ. 1 (1983).

108 It should be noted that the "self-provisioning market" can be served with either license-exempt or exclusively-assigned frequencies.
Even the FCC, which continues to practice it, argues against it.\footnote{The Task Force concluded that the Commission can best promote economic efficiency by providing spectrum users with flexibility of spectrum use and ease of transferability in order to allow maximization of the value of the services provided.” SPTFR 2002, supra note 14, at 21.} The truncation of rights issued to economic agents results in spectrum being utilized to produce far less valuable output than what would obtain in a market with more extensive, and more flexible, spectrum use rights. This resembles the tragedy of the anticommons in the result of under-utilization of radio spectrum, but this anticommons problem actually stems from a separate tragedy of the commons taking place with regard to regulation. There is a failure to define the necessary use rights and to distribute them to economic agents because spectrum allocation reforms constitute public goods, which are undersupplied when the gains from productive investments (such as legislative lobbying) are largely appropriated by free riders. Regulation, subject to the tragedy of the commons, results in an inefficient rights structure that then triggers a tragedy of the anticommons in wireless markets.

Unlicensed allocations can also trigger observable multi-dimensional tragedies. Unpriced access can, as elsewhere, lead to over-use when demand is insufficiently rationed by use restrictions. Conversely, regulations themselves impose inefficiencies. In fact, the blunt instruments available to regulators—most generally, power limits—raise costs for many applications, even when higher power levels would not impose costs on other (licensed or unlicensed) users. Regulatory standards, however, are difficult to customize and, given administrative inertia, difficult to update. These rigidities are especially important when state of the art technology is rapidly changing.

In some cases, the instruments rationing unlicensed spectrum access encourage the widespread use of radio devices. This is seen in popular use of the 900 MHz and 2.4 GHz unlicensed bands. Yet wide area networks have developed in such bands only sporadically, and are largely limited to sparsely populated rural areas, due to the costs imposed by use regulations, on the one hand, and potential congestion, on the other. An entrepreneur anticipates that, should a given wireless application over a wide area (i.e., beyond the geographic space controlled by a homeowner or enterprise) succeed commercially, entry by rivals is likely. This will increase the likelihood of costly conflicts, and raise the expected cost of coordination. While voluntary arrangements or advanced technology deployments can often remedy particular congestion problems, restoring quality of service to the level prevailing prior to the arrival of a new operator, such fixes are not supplied for free. The costs act as a tax on those deployments considered vulnerable, as investors rationally project losses resulting from increased airwave contentiousness.

New network formation is thereby suppressed, even when demand is sufficient to justify its costs, due to the insecurity of airwave rights. Because future interference would depreciate the value of capital, investors avoid the
creation of wireless communications systems that would be built in the presence of exclusive spectrum rights. This reaction is evidenced among those contemplating potential entry, and results from inefficient rules rather than the protection of incumbent rents.\textsuperscript{110}

The importance of spectrum rights that grant protection from interlopers is seen in the evolution of the WiFi standard itself. The emerging WiMAX platform extends the WiFi technology, allowing for much wider signal coverage. This is intended to enable network operators to serve areas as far as thirty miles from a transmitter. WiFi hotspots, in contrast, have a radius of under 100 feet in most practical deployments.\textsuperscript{111} It is noteworthy, then, that WiMAX is being advanced as a licensed service in metropolitan areas. Its supporters—most notably, Intel—believe that radio interference would inefficiently limit its usefulness.\textsuperscript{112}

The over-grazing metaphor that dominates discussion of the tragedy of the commons often leads to confusion. Critics of certain rights regimes highlight problems by pointing to visible resource depletion; in spectrum, this unfolds as a critique of unlicensed bands by reference to the interference problems that develop among users. Proponents then argue that conflicts are either not in evidence, or are easily manageable. In fact, a marketplace with zero conflict could nonetheless host an extremely costly common interest tragedy.

This would occur where network investment was constrained by access rules that unproductively lower the returns anticipated from the ownership of sunk capital. Such capital, complementary to the use of radio spectrum, is

\begin{footnotesize}
\begin{itemize}
\item \textsuperscript{110} Conversely, the entry deterred generally protects incumbents' rents. This is seen empirically in examining wireless license values internationally. Countries awarding the most extensive property rights to wireless operators see significantly lower market prices for wireless licenses, a result explained by the greater competitive pressure anticipated to result from an expanded property rights regime in radio spectrum. HAZLETT, supra note 12.
\item \textsuperscript{111} BELK, supra note 90, at 12.
\item \textsuperscript{112} "In congested urban areas, licensed services may be the best way to proceed in order to encourage deployment, ensure optimal quality of service, and manage interference." Peter Pitsch, The Future of Radio Spectrum Policy, TECHNOLOGY @ INTEL MAG., Feb.-Mar. 2004, at 1, 4, at http://www.intel.com/technology/magazine/standards/st02041.pdf (last visited Mar. 26, 2005). A manufacturer of wireless broadband equipment, Alcatel, goes further, suggesting that important WiMax deployments will everywhere gravitate to licensed spectrum—if it is available:

Although 2.4 GHz and 5 GHz non-licensed bands are largely available, their usage could be limited to trials because of the risks of interference preventing QoS [quality of service] commitments.

The 2.5 and 3.5 GHz licensed bands will be the most common bands for WiMAX applications.

Most countries have already allocated licensed spectrum, generally to alternate operators. Nevertheless large quantities of spectrum are still in process of allocation, and some countries have not even defined any WiMAX licensed bands yet.

ALCATEL, WiMAX: MAKING UBQUITOUS HIGH-SPEED DATA SERVICES A REALITY 5-6 (2004), available at http://www.alcatel.com/com/en/appcontent/apl/S0406-WiMAX-EN_tcm172-44791635.pdf (last visited Mar. 10, 2005). This underscores the fact that the use of unlicensed bands can be attributed, in part, to the unavailability of alternative licensed bands. The delays in allocating and licensed exclusive rights is a regulatory transaction cost distinct from market transaction costs. The latter include bargaining problems that may develop after rights have been clearly defined and issued to economic entities.
\end{itemize}
\end{footnotesize}
reduced. The social losses from the services not made available to consumers constitute economic loss. Hence, the tragedy of the commons is quantified as the benefits society would obtain under a more productive rights structure.

When the government sets aside bandwidth for unlicensed users, at least two potential sources of resource misallocation arise. First, the government imposes a regulatory regime that may block more valuable economic activity than it encourages—the social loss identified as the essential common interest tragedy above. Second, the governance regime established will be difficult to contract around, given that spectrum access rights are distributed so widely as to make negotiation among interested parties expensive.

The dispersed, localized rights structure of the unlicensed regime allows some important technological migration to occur. Transitions rely on coordination through the equipment market, as when IEEE standards are amended to incorporate new opportunities. In spectrum, with exclusively assigned rights, the same equipment market coordination takes place in addition to that supplied by competitive spectrum owners.

This added scope in the rights awarded wireless licensees has proven important in actual technology migrations. In cellular telephony, for instance, a transition from analog to digital networks in the 1990s was achieved seamlessly because operators, internalizing the gains from more efficient (digital) spectrum use, invested aggressively in new architecture and widely distributed new phones. These carriers were also careful to manage the transition, having flexible rights to gradually shift spectrum usage from analog to digital. In 1996, virtually all 38 million U.S. wireless subscribers received analog service. By 2003, wireless subscribership had grown to 148 million, and all but approximately twelve million were using digital technology.

Tens of millions of subscribers have been migrated to entirely new networks, without organization difficulty, due to the exclusivity of CMRS spectrum rights.

In contrast, the digital TV transition managed by regulators is soon to enter its third decade with virtually no progress made. Instead of spectrum holders changing out technologies to increase the value of services offered, government mandates how TV stations and buyers of television sets will invest billions of dollars in order to switch formats. The outcome is that interested parties are not much interested, and key players—e.g., broadcast stations—find that they can extract rents by non-cooperation (hold-up).

113 IEEE stands for the Institute of Electrical and Electronics Engineers, an important standards-setting body in radio frequency applications.
115 Id.
Each block of frequencies set aside for unlicensed use entails opportunity costs, because certain alternative uses of those frequencies are prohibited. Imagine a situation in which unlicensed users could realize substantial social gains by collectively changing unlicensed rules—in the limit, by aggregating all the band’s use rights and awarding them to a single wireless network operator. (Of course, there are many variations here. Multiple operators could be awarded competing rights. Rights could be assigned by auction, or via a long-term service contract with stipulated performance and pricing formulas. And so on.) This would allow advanced wireless services to be supplied for the benefit of consumers, who would be better off with this reorganization.

Such restructuring will not occur, because unlicensed users have highly fragmented spectrum use rights and transaction costs are prohibitive. Only governmental administrative process—“command and control”—can impose such transfers. Unlicensed allocations, as provided for in the current regulatory regime, carry with them the costs and benefits of this form of decision-making.

Even where shifting market realities allows for new forms of market organization to exploit new opportunities, spectrum use rights are widely dispersed and cannot be reassembled short of a new regulatory mandate. Conversely, exclusive rights allow market competitors to fix and change industry structure. Included in the opportunity set are both the rules and applications commonly associated with unlicensed allocations.

III. Conclusion

Common interest tragedies occur in both licensed and unlicensed radio spectrum allocations. They stem from fragmentation of rights such that the efficient level of coordination between spectrum users is deterred. The anticipation of such a result will, ex ante, cause investors to provide less complementary infrastructure than in an optimally structured rights regime. And, due to the public good aspect of regulatory reform, more efficient rights structures are under-supplied, leaving the “market failure” uncorrected.

Alternatively, market failure is avoided in the intensely utilized radio spectrum coordinated via property rights. With exclusively-assigned, flexible-use spectrum (EAFUS) allocations, operators create substantial national networks, deploy advanced technologies, compete to drive down costs, and coordinate extremely complex spectrum sharing arrangements. Marketplace evidence indicates that the CMRS band, with the most liberal use rights in place, produces annual consumer surplus exceeding $80 billion, and further evidence suggests that additional EAFUS bands have very high social value both absolutely and relative to alternative incremental uses of radio spectrum.16

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116 In an econometric model estimated on wireless phone market data from twenty-nine countries, HAZLETT & MUNOZ, supra note 39, at 32, show that an additional 60 MHz of spectrum made available under CMRS rules would have generated $24 billion in annual gains for U.S.
U.S. regulators, however, have effectively halted EAFUS rights allocations since PCS licenses were authorized in 1994. FCC analysts have identified 438 MHz in the prime frequencies below 3 GHz which could be so designated even while avoiding spectrum allocated to broadcasting, unlicensed, public safety, or government uses. In the interim, 555 MHz (in the 5 GHz band) has been set aside for unlicensed use in two separate rule makings (in 1997 and 2003), and several proceedings are now in process to make additional spectrum available for unlicensed use. In some of these, the Commission expresses an explicit preference for unlicensed over licensed allocations. In others, the effect would be to transfer spectrum currently used by licensees to unlicensed use.

These decisions substitute governance for exclusivity. The costs and benefits of this policy preference should be fully evaluated, particularly with respect to the implications of market failures associated with fragmentation of property rights. Eliminating ownership removes the opportunity to directly observe valuations in market transactions. It has also been seen to raise the cost of coordinating technology and infrastructure investments, as well as usage patterns in spectrum access. Understanding the nature and extent of common interest tragedies should help to inform the relevant policy choices in radio spectrum regulation.

consumers. This results from a decline in price per minute for wireless phone service of about 20%.

120 In its proposed rule making in 3650-3700 MHz, the Commission considers allocating 50 MHz of nationwide spectrum—virtually all of which has been left idle in a band allocated for satellite downlinks that occur only on the East and West coastlines—for new uses. It proposes to allow unlicensed use according to sharing rules it will draft, rejecting requests to allow licensed uses, on the grounds that the latter would interfere with the former. "[W]e believe that even a moderate presence of potentially ubiquitous terrestrial services under a licensed allocation could hamper or preclude the operation of unlicensed devices in large geographic areas—especially rural America where the need is greatest. Therefore, our initial proposal to allow unlicensed operation" precludes licensed use. The Commission went on to request input on the matter. Unlicensed 3650-3700, supra note 72, para. 21.
121 This is the proposal in the Interference Temperature proceeding, see supra note 73.