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MARKET ALLOCATION OF RADIO SPECTRUM

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EXECUTIVE SUMMARY

Markets for radio spectrum have been advocated by economists since Ronald Coase (1959), but policy makers have often seen the policy as untested. However, incremental reforms in specific non-broadcast services, most importantly in cellular telephone networks, have broadly expanded the spectrum use rights granted to market competitors, and have thus created the possibility to observe the allocation of airwave rights by market forces. Many lessons are observable. For instance, the U.S. transition from analog to digital mobile phone networks, downloaded entirely to carriers, was efficiently undertaken while seamless to consumers and policy makers. This contrasts vividly with the parallel technology migration being directed by government regulators in the TV band, where property rights to spectrum are severely truncated. There, enormous social costs are imposed by centralized control of frequencies, not only in the long delays blocking digital technology adoption (two decades and counting), but in the severe misallocation of TV band airwaves that will persist after the digital TV transition is completed.

With well-defined resource owners, competitive markets impose rational assessment of economic trade-offs, improving productive use of the natural resource of radio spectrum and the complementary infrastructure that enhances wireless applications. With effective control over allotted frequency space, wireless phone carriers invested heavily to upgrade networks and users' handsets to advanced technologies, managed spectrum sharing, priced access to encourage efficient traffic flows, and—at each step—carefully weighing costs and benefits. Conversely, with government control over broadcast frequencies, where traditional licenses lock TV stations into solutions dictated by regulation, reallocating bandwidth turns into a rent-seeking game. Regulators do not internalize the benefits they create nor the costs they impose. Instead of optimizing resource use, players fight to exert regulatory influence, blocking entrants and protecting existing market structures. This game takes on a life of its own—rolling out twenty-year "transitions" to produce a terrestrial television product that, while ongoing, has already been abandoned by the vast majority of U.S. households which now subscribe to cable or satellite TV subscription services. The result is that VHF-UHF spectrum that could host extremely valuable products for consumers is squandered.

The standard spectrum allocation approach posits three alternative models: "exclusive use," "commons," and "command-and-control." The regulator's role is specified as selecting between these models case-by-case. This framework, however, yields the anti-consumer outcomes widely associated with traditional regulation. The analysis of property rights found in the law and economics literature offers clarification. It demonstrates that the conventional approach mistakenly conflates *access regimes*, rules coordinating wireless usage, with *property regimes*, rules determining who is authorized to make such choices. The debate over spectrum allocation policy will gain coherency when, rather than seeking to impose preferred spectrum access regimes, public policy enables a competitive market process to discover them. This requires moving away from case-by-case administrative allocations to a general regime of exclusive property rights.

Failure to do so comes with a great cost. For example, the 3650-3700 MHz band is situated in the dominant band for wireless broadband equipment sales world wide, yet the band is mired in an FCC proceeding that prevents it from being utilized in the U.S. In another example, assuming the U.S. digital television band transition concludes successfully, significant amounts of spectrum in the TV band—the so-called "white space"—will be available for non-broadcast uses. The FCC is in the process of deciding how to use the TV band white space for unlicensed use, mandating sharing rules, including power limits and protocols. This is a "command-and-control" choice that positions the FCC—not parties facing economic competition—to choose the optimal access regime. Despite compelling marketplace evidence that the marginal value of additional unlicensed allocations are far outweighed by the social benefits likely to accrue from the creation of exclusive, flexible ownership rights, resulting losses from unlicensed allocations will not be borne by the regulators who impose them.

Instead of imposing a plan for its preferred access regime governing white spaces, the regulatory agency should exhaustively allocate TV band spectrum to owners exercising broad property rights. Incumbent (digital) TV stations could be grandfathered as rights holders, and white spaces allotted to overlays permitting new spectrum owners (assigned, presumably, by auction) the opportunity to competitively reorganize the TV band. With frequencies assigned to responsible economic agents possessing direct incentives to supply productive wireless services for consumers, internalizing costs and benefits of infrastructure investment and spectrum use, the true opportunities for TV band reallocation will be revealed. Firms, non-profit organizations, and public agencies will then be able to assess, and to remedy, situations in

which any particular access regime is under-supplied. Thus, the spectrum market solution rationalizes the deployment of alternative frequency coordination methods.

1 INTRODUCTION

In the United States, major-city cellular telephone licenses covering about 80% of U.S. population were awarded 1984-86. These authorizations mandated that wireless systems be built using an analog radio standard.[1] In 1988, however, regulators relented, and permitted cellular licensees to deploy their choice of digital communications technology. While tens of billions of investment dollars had already been spent to create analog networks, and millions of subscribers had begun using those telephone systems, operators were given flexibility in how they transitioned network infrastructure and customer handsets to more advanced technologies. This approach, essentially granting *de facto* property rights to network owners over the frequencies allocated to their licenses, allowed a complex transition from analog to digital services in the original 50 MHz of spectrum allocated to cellular licenses. By 2006, virtually all cellular usage had migrated to digital standards.[2]

In contrast, a 1987 initiative by the U.S. regulatory agency, the Federal Communications Commission (FCC), launched a transition to "advanced television services." This policy seeks to end analog TV broadcasting, for which 402 MHz have been set aside by regulators, in favor of digital TV broadcasting, for which 294 MHz are reserved. The transition, now in its twentieth year, has yet to occur. While TV stations have been mandated to broadcast their programs in both analog and digital over-the-air formats, nearly 90% of U.S. TV households have migrated to cable or satellite TV reception, bypassing terrestrial broadcasts. Regulators have imposed requirements on TV sets, forcing all consumers of TV receivers to absorb the cost of off-air digital tuners, despite the lack of interest by most households in using such devices. A 'turn off' of analog stations is now, by legislation, set for February 2009; this is subject to change. But the underlying reality of greatest importance, perhaps, is that even if the digital switch is successful on its own terms, the U.S. will move past 2009 with nearly 300 MHz of prime radio spectrum deployed in the service of over-the-air television, a delivery platform rejected by nine of ten U.S. homes. Instead, these homes elect to pay subscription fees in order to opt out of the "free" video programming distribution network imposed by government regulation. In alternative uses, such as providing additional bandwidth for cellular telephony or wireless broadband, the nearly 300 MHz "consumed" post-transition by the VHF-UHF TV broadcasting allocation imposed by regulators amounts to hundreds of billions of dollars in lost consumer welfare.[3]

The vivid contrast between the analog-digital transition in cellular and the analog-digital transition in broadcast television illustrates the social utility of private property rights to radio spectrum. With well-defined resource owners, the power of competitive markets can be unleashed to enforce efficiencies and unlock innovative uses for both the natural resource of radio spectrum and the complementary wireless technologies that facilitate its productive use. With control over "their" allotted frequency space, wireless phone carriers invested heavily to upgrade networks and users' handsets to advanced technologies, carefully weighing the costs and benefits. The constraint of competition from other carriers insured that alternative methods were tried, and potential innovation given its proper trial. Yet, with government control over broadcast frequencies, where traditional licenses lock TV stations into solutions dictated by regulation, reallocating bandwidth turns into a rent-seeking game. Instead of optimizing resource use, players fight to exert regulatory influence, blocking entrants and protecting existing market structures. This game takes on a life of its own—rolling out twenty-year "transitions" to produce a terrestrial television product that, well before 2009, was abandoned by most consumers, while ignoring extremely valuable options for alternative spectrum uses.

Although a much older idea,[4] for the past decade it has been well recognized that more market mechanisms in spectrum management would lead to greater efficiencies.[5] It is interesting, therefore, how confused the debate has become over market allocation of radio spectrum. Take the simple proposition that, where scarcity prevails, efficient resource use is achieved via well-defined property rights.[6] The argument is introduced that scarcity no longer obtains (if it once did) with respect to radio waves, and that additional bandwidth should be made available for license-exempt spectrum use. But a set-aside of unlicensed bandwidth is itself the imposition of a property regime which addresses potential conflicts between rival users in order to limit resource dissipation. Unlicensed rules explicitly seek to exclude certain uses, power levels, or technologies in order to regulate a scarce resource—an asset whose economic value is improved by effective (state) ownership.[7] In this case, the ownership is asserted by the government, however, which regulates access (and thereby excludes) largely by controlling the equipment market.

With respect to the alternative path, which delegates exclusionary rules to private property owners who then compete to provide alternative means of organizing resource use, the discussion is similarly disjointed. Property rights are, as a general matter, limited by law (real property owners cannot absolutely exclude all competing uses of land, e.g., being limited by easements, emergency encroachments, or *de minimus* transgressions such as that imposed by a silent airplane flyover). Yet, instead of evaluating the means by which such rights are generally created and the resulting economic activity that occurs in wireless markets, such that rational choices can be made in designing legal institutions, current regulatory approaches are implicitly advanced by arguments emphasizing how private spectrum rights should be truncated.

Consider, for two instances, criticisms of spectrum markets that rely on "warehousing" and "transaction costs." Warehousing is often advanced as a reason why private ownership of radio spectrum is not in the public interest. Warehousing on a massive scale is what traditional spectrum allocation administrations (in the U.S. and most other nations) currently achieve. To decentralize property rights among competing profit-maximizing owners is to impose costs on the parties responsible for warehousing, thereby reducing its incidence. To the extent that warehousing is a spectrum market problem, standard competition policy remedies are implicated; these can be considered, moreover, precisely due to the transparency created by eliminating monopoly control over spectrum by regulators.

Transactions costs are also asymmetrically associated with private market activity. Hence, a 2003 FCC study notes that:

> In exchange for operating on an interference sufferance basis, unlicensed devices are free from the burden of the normal delays associated with the licensing process and, as a bonus, spectrum use is free of charge.
>
> In the end, consumers reap the benefit of lower costs, less hassle (no need for a license to operate the device), and more rapid development cycles.[8]

First, the "normal delays" in licensing are entirely endogenous. Regulatory mechanisms distribute exclusive spectrum rights, to the extent they are available under the traditional administrative allocation system, and the argument for liberal reform—the argument we make in this paper—is that such delays should be eliminated by a regime shift away from administrative allocation. Second, spectrum use is not "free," but imposes costs in the loss of value associated with excluded opportunities. When the U.S. government allocated 30 MHz to unlicensed PCS (personal communications services) in the 1990s, this imposed a substantial social cost, depriving mobile phone networks of scarce bandwidth with which to expand and enhance voice and data delivery. And third, the transaction cost implied for exclusive rights, that there is "less hassle (no need for a license to operate the device)," is incorrectly advanced as a unique outcome of unlicensed spectrum. In wireless markets, cellular operators effectively own airwaves, and sell access to subscribers. No license is needed by 2.5 billion global mobile phone subscribers. More generally, wireless networks allow extremely complicated sharing of allocated bandwidth between equipment makers, voice networks, data networks, application providers, network overlays (say, like Blackberry or On-Star) and rival consumers. As seen in market transactions, not only are these costs not prohibitive, they look very little like the contentious and unproductive regulatory skirmishing that passes for "interference" adjudication at regulatory agencies, and which is often mistaken as a proxy for spectrum rights definition.[9]

An iconic example of the current debate about market mechanisms in spectrum management is found in the U.S. Federal Communications Commission's Spectrum Policy Task Force Report ("SPTF Report") issued in November 2002. In summarizing conventional thinking about the regulator's role in radio spectrum allocation, it defined the regulator's spectrum allocation task as selecting among three alternative models, which it defined as follows:

- "Exclusive use" model. A licensing model in which a licensee has exclusive and transferable flexible use rights for specified spectrum within a defined geographic area, with flexible use rights that are governed primarily by technical rules to protect spectrum users against interference.

- "Commons" model. Allows unlimited numbers of unlicensed users to share frequencies, with usage rights that are governed by technical standards or etiquettes but with no right to protection from interference.

- "Command-and-control" model. The traditional process of spectrum management in the United States, currently used for most spectrum within the Commission's jurisdiction, in which allowable spectrum uses are limited based on regulatory judgments.[10]

The SPTF Report's policy proscription is that each of the models has its appropriate place, and that regulators should examine frequency use possibilities case by case. This view point suggests that a band governed by the "exclusive use" model may be situated next to a "commons" band, but surrounded by blocks of spectrum under the "command-and-control" structure. The SPTF Report suggests that while the government should generally move away from the rigid rules of "command-and-control", circumstances in each wireless application will be determinative.

This paper attempts to outline how this policy choice framework confuses *access regimes*—how resources are employed by consumers and producers—with *property regimes*—how control over organizing choices is defined. While "exclusive use" and "commons" are recommended as liberal alternatives to traditional regulation, the bureaucratic selection process favored by the SPTF Report that continues to impose regimes, block by block, *constitutes* "command-and-control." Some forms of wireless market organization are chosen, and others excluded, not by competitive markets but via administrative allocation.

This approach is revealed by considering the law and economics literature on the general evolution of property rights. Before considering this alternative analytical framework, however, some consequences of the conventional approach are considered.

2 THE CONVENTIONAL TRICHOTOMOUS FRAMEWORK

The SPTF Report's framework ineptly defines spectrum allocation policy. First, the exclusion uniquely associated with "exclusive use" is not unique—it is just as essential to "commons" or "license-exempt" bands and to the "command-and-control" approach. In each instance, government prohibits certain wireless activities so that others are more productive. "Exclusive use" leads to intense "spectrum sharing" in the cellular bands, for instance, where liberal use rules yield licensees *de facto* spectrum ownership rights. Conversely, unlicensed rules impose limits on users that, for example, exclude extremely valuable CDMA spread spectrum networks, as well as extremely valuable TDMA networks. In either case, exclusions are employed to facilitate "spectrum sharing." The essential difference lies in the nexus of control: what parties evaluate the trade-offs.

Second, the analysis for policy selection is fatally flawed. Basic property rights do not uniquely determine the organization of the market. Many automobile drivers purchase their vehicles, some enter long-term leases and yet others use short term rental contracts. Furthermore, suggesting that a certain type of spectrum access is beneficial does not imply that the government should thereby impose that use. We would be appalled by a proposal to require leasing as the only option to acquire a car. The error is vividly drawn in the FCC claim that the government should set aside unlicensed bands on the grounds that public parks generate net social value:

> A mechanism based on markets, such as an exclusive use model, will be most efficient in most cases. However, government may also wish to promote the important efficiency and innovation benefits of a spectrum commons by allocating spectrum bands for shared use, much as it allocates land to public parks.[11]

In fact, the government does not generally allocate land, but defines ownership rights. Such private property rights enable government to then create public parks. The means by which state agencies acquire land rights (first appropriation, purchase, condemnation, or gifting) are of ancillary importance here.[12] What is primary is that the land market actively benefits economic decision making even when the ultimate access regime is a "commons."

A land market sorts out the best uses of land by allowing competing uses to vie for specific parcels of land. Land is free to migrate from agricultural to urban uses or to be set aside by its owner (possibly with financial inducements from the government) for environmental uses. This ability for land to find its highest valued use is facilitated by general property rules.

First, general property rules eliminate barriers to productive use of assets, such that society need not wait for the state to set resource access rules parcel-by-parcel. This actively advances competition in services and fosters innovation.

Second, the asset market provides information as to the opportunity cost of alternatives. One can observe how much additional acreage would cost New York City, should it seek to expand Central Park, or how much revenue it could generate by selling a slice of it.[13] Without private property rights in land, these values are concealed, and the government agency supplying the amenities of a public park lacks necessary inputs—specifically information—for efficient decision-making. This is the central short-coming encountered in planned economies, the so-called socialist calculation problem.

Third, eliminating entry barriers imposed by government "command-and-control" spectrum allocation allows alternative technologies and business plans to be tested in the marketplace. It is this discovery process, where costs and benefits are internalized by responsible economic agents (i.e., asset owners), that reveals efficient means of organizing wireless markets. Less exclusive ownership rights also permit investments and transactions, but they limit the scope of the discovery process. The power limits imposed by government in unlicensed bands enable some useful forms of coordination and experimentation to occur, but not others.

Transactions between resource owners reveal the cost of any one particular market design. Trial and error is fundamental, as innovative consumer-pleasing advances inevitably emerge from uncertainty. The

distribution of exclusive ownership rights enables a diversity that encompasses technologies, services, business models, and cooperative structures. The property rights structure does not preclude a "commons," but rationalizes it.

3 PROPERTY RULES: THE LAW AND ECONOMICS APPROACH

In 1967, Harold Demsetz asked, *why do we see exclusive ownership of some resources, but not others*? He offered a simple model wherein property rights are costly to define and enforce, and so come into being when their benefits exceed their expense. Demsetz reasoned that it was efficient for native tribes in Canada to treat the beaver habitat as open to all when demand for skins was quite limited, and then likewise efficient for exclusive rights in beaver hunting grounds to emerge when the European fur trade was introduced, increasing the benefits associated with conservation and ownership.

This approach has widely influenced scholars seeking to understand how rules governing economic activity evolve. Four basic property regimes have been defined:

- Open Access, which allows exploitation without limit;
- State Property, which limits use via rules crafted by government officials;
- Common Property, which limits use via rules crafted a group of owners;
- Private Property, which limits use via rules crafted by a single owner.[14]

In general, individuals behave differently under the incentives of alternative property regimes. Economic agents also realign incentive structures by reconfiguring rights. Hence, private property evolves into common property when a corporation is created with the private assets of common shareholders, and state property emerges from common property when a government agency purchases land from a corporation.

The optimal property rights regime permits beneficial coordination of economic activity. The "tragedy of the commons," better thought of as a "tragedy of open access," results when users who could benefit from conserving resources are stymied. This is often framed as a "transaction costs" issue, or one of "ill-defined property rights."

With spectrum, government policy states that it aims to "minimize interference." In fact, potential conflicts are a byproduct of any wireless activity; efficient rules maximize the total value of wireless applications rather than minimize disruptions. Efficiency demands that each dollop of interference take place where the benefits of the activity causing the conflict exceed the damages imposed.

In the U.S., and virtually everywhere else, the basic spectrum property regime is best described as state property, also known as "administrative allocation." This regime defines spectrum use rights for other parties, as when "exclusive use" spectrum rights are now assigned by auction, traditional licenses permitting only specified activities and technologies are authorized, or unlicensed bands are set-aside for users of FCC-approved equipment. Further reconfiguration of use rights then evolves. In Wi-Fi hotspots, for instance, "commons" spectrum rights are defined by the state, but access to local area networks is often denied non-subscribers.

In U.S. cell-phone networks, the state has awarded exclusive rights that are relatively liberal, approximating *de facto* private spectrum property. Operators select technologies, network architectures, and price schedules. This discretion is employed to re-assign "exclusive use" rights to third party vendors (such as handset makers), application or content providers (say, to send pictures or music downloads), rival networks (e.g., Blackberry), and, of course, subscribers. The licensee creates an access regime that allows millions of disparate parties to share airwaves, using significant sunk capital provided by long-term investment. This infrastructure, a complementary input to spectrum in the provision of wireless services, is a key component in the productive deployment of spectrum. The absence of such infrastructure may constitute a "tragedy of the commons" that exceeds the destruction of social value via over-use or "interference."[15]

Unlicensed bands are not "commons," but are administratively allocated. The mechanism used to coordinate spectrum use is equipment regulation, most generically consisting of power limits. These are an exclusionary device, separating users geographically as radio waves attenuate over distance. The intent of such rules is to privatize airwaves in local areas, allowing users to coordinate their activities by re-using frequencies from place to place for such devices as cordless phones or Wi-Fi routers.

In an actual commons, owners set access rules and then internalize costs and benefits from resource use. In unlicensed spectrum, rules are imposed to determine basic resource appropriation issues by an outside party—the regulatory agency. Resource costs or benefits are internalized only as they are communicated

politically. Our experience with "public interest" spectrum regulation underscores that these decisions characteristically squander rich possibilities for productive utilization of airwaves.[16]

That spectrum has been usefully exploited under some allocations imposed via the "commons" framework fails to remedy the anti-consumer consequences. It is well known that the traditional licensing regime governing TV broadcasting has also produced socially useful services. Americans purchase some 25 million TV sets annually, investing about $8 billion[17]—far more in these receivers than in, say, Wi-Fi routers or modems.[18] The TV band is nonetheless a textbook example of socially wasteful under-utilization (over-allocation) of radio spectrum. Bandwidth with very high value in alternative employment is set aside by government planners for an over-the-air delivery platform that nearly 90% of U.S. households pay to bypass via cable or satellite. Given that the incremental cost of moving to 100% cable and satellite distribution for broadcast TV content is on the order of just $3 billion,[19] while the social value of the 402 MHz now walled off for broadcast TV services is likely to exceed $2 trillion,[20] the state property regime for radio spectrum dissipates (vast) net social value. The willingness of consumers to purchase millions of devices that can use these frequencies does not mitigate this anti-consumer outcome.

4 MAXIMIZING THE SOCIAL VALUE OF WIRELESS

The FCC believes that "[t]he Commission's rules for unlicensed transmitters have been a tremendous success,"[21] and that the policy implication is that it should allocate more spectrum for unlicensed use. The logic mimics the view that, given that there are 2.7 TV sets per U.S. household,[22] the government should allocate more spectrum to the TV band.

The FCC's approach to incremental unlicensed allocations lacks the multi-layered analysis needed. The first layer identifies the appropriate margin. The productive use of one set of frequencies does not imply gains from additional bandwidth. South Korea is known to have the highest concentration of Wi-Fi hotspots in the world, but utilizes only the 2.4 GHz ISM band. Regulators there have yet to authorize either the 1997 U-NII or the 2003 U.S. allocations for unlicensed devices in the 5 GHz band, some 555 MHz in aggregate.[23] This implies that, despite the popularity of inframarginal allocations, incremental unlicensed bandwidth may not be particularly productive. The limited economic activity observed in the unlicensed 5 GHz or PCS bands (30 MHz in the 2 GHz band allocated in the mid-1990s) in the United States is consistent with this view.[24]

Any examination of the incremental allocation margin between licensed and unlicensed uses in the U.S. finds the balance in favor of additional licensed spectrum.[25] The benefits of additional flexible use licensed allocations are an order of magnitude greater than for additional unlicensed allocations.[26] The trade-of measured is between access models. The calculus should be performed by market participants (with government actors among them) rather than by "command-and-control" administrators deciding which of the two currently preferred access models to apply.

A second layer of analysis identifies the property rights alternatives. Wireless activities are not uniquely associated with particular regimes. Unlicensed devices such as Wi-Fi routers or cordless phones can use licensed frequencies; cellular phone service can be supplied using licensed bands (as it typically is) or unlicensed frequencies (as it is for some links created via multi-mode handsets).

Assuming, *arguendo*, that additional bandwidth for a spectrum "commons" is desirable, it is yet necessary to devise a path to that end. One mechanism is to impose, by regulatory fiat, unlicensed access rules. That is the implication of the SPTF Report's tripartite decision tree. But this approach fails to incorporate secondary rights reassignments. For instance, by assigning spectrum ownership, "commons" could be created where profitable opportunities are discovered. Importantly, competitive market forces would search, test, and reveal a variety of alternatives, gauging their value. As FCC spectrum analysts Evan Kwerel and John Williams write:

> Future expansion of dedicated spectrum for unlicensed use could be obtained through negotiation between the manufactures of such devices and spectrum licensees…. Competition between licensees would ensure that fees reflect the opportunity cost of the spectrum. Alternatively, manufacturers of low power devices might form a bidding consortium to acquire additional spectrum in our auction. If there is a continued desire as a matter of public policy to provide spectrum for such devices on a "free" basis, the FCC itself might purchase the spectrum in the auction, essentially reducing overall proceeds to the Treasury. This would have the advantage of making the opportunity cost of such allocations more explicit.[27]

What the FCC calls a "private commons" is not simply a theoretical possibility. Privately managed cellular networks organize complex spectrum sharing, equipping customers with handsets, frequency access rights, and wireless network infrastructure in exchange for subscription fees. Some access is "free" (e.g., within-plan, on-net, or off-peak minutes, as well as text messaging and all 911 calls), and customers use the network without discrimination.

To the extent that cellular networks are liberally regulated, the market adopts organizational modes serving consumer interests. Included here, most notably, is the demand by customers to utilized extensive fixed network infrastructure. The transaction costs of providing wide-area network investments under unlicensed rules are relatively high, depriving consumers of desirable options.

The third layer of analysis considers the spectrum allocation process as a whole. What are the implications of allocating spectrum in the current tripartite case-by-case versus a liberal ownership regime? The

consensus of economists is that the latter eliminates the barriers to competition posed by the current system, permitting rational economic decisions to be made.[28] This does not reflect a preference for one type of market organization over another; economists are agnostic as to what type of network architecture, or non-network wireless devices, are optimal under various circumstances. As Kwerel & Williams offer, in their argument for a "Big Bang" endowing an active spectrum market:

> One possible arrangement would be for a licensee or group of licensees covering a particular band throughout the U.S. to charge manufacturers a fee for the right to produce and market devices to operate in that band. Such contracts could provide different grades of access for different fees, thus providing for a wider range of uses than are possible under the current rules.[29]

The passage suggests two critical considerations. First, there are myriad ways to coordinate wireless use, even assuming an "unlicensed" structure. The trial and error of the market is a reliable mechanism for testing alternatives.

Second, it is not efficient to impose designated market structures. The *arguendo* assumption made above disrupts consumers' interests. When the state imposes rules on licensed or unlicensed use, consumers and producers are constrained, limiting the search for improved, innovative modes. To assume that only by government regulation can such a "commons" be provided is to mistake an access regime for a property regime. And to assume that forcing a particular set of unlicensed rules on spectrum users creates efficiency is to ignore the underlying characteristic of administrative allocation: that the state lacks the information or incentives to effectively evaluate the trade-offs between rival alternatives.

The pro-consumer policy framework dispenses with the state's case-by-case rule makings, a process reliably cumbersome and protectionist. Instead, exclusive rights to spectrum should be generally distributed to owners. No doubt, some of these owners will be public agencies. The unlicensed bands which host wireless devices, such as the 902-928 MHz and 2.4-2.4835 GHz bands, would be fairly certain to remain, as they are today, *de facto* state property.

Indeed, the reallocation of unlicensed bands is difficult due to the transaction costs unlicensed rules generate. The transactional efficiency of ownership rights is that a responsible party—not the FCC—is enabled to coordinate spectrum sharing. This is widely misunderstood. "Licensing costs" are characterized as an expense associated with the award of exclusive rights,[30] but these are a byproduct of the regulatory system, and are entirely remedied by more efficient *government policy*. The *marketplace* costs of trading exclusive rights are modest in the wireless phone market, where over 5 trillion minutes of use are purchased by global customers each year.

The source of transactions costs is shown in the Nextel story.[31] The FCC had assigned Specialized Mobile Radio (SMR) licenses delivering dispatch services. Because the SMR band, allocated about 19 MHz, was adjacent to the cellular bands, and because cellular license prices revealed the service to be very valuable in the mid 1980s, a former FCC lawyer named Morgan O'Brien noted an opportunity. He purchased SMR licenses in secondary markets, and used the market data on opportunity costs to figure out what the FCC could not. That the SMR bands, if deployed with a cellular architecture and digitized, could provide superior dispatch services and yet have abundant capacity to provide cellular service. The firm O'Brien founded, Nextel,[32] obtained license waivers permitting the upgrade. What was virtually worthless spectrum was reborn as the key input in cellular service for 16 million subscribers. The company was purchased by Sprint for $35 billion in 2005.

Notably, Nextel aggregated over *40,000 SMR licenses*,[33] incurring transaction costs that could have been avoided had the FCC issued fewer licenses. In the event, the company's value was created by aggregating unproductive spectrum rights, creating an advanced, complementary nationwide network (requiring an FCC deregulation), and then re-assigning the spectrum rights to consumers. It is often claimed that markets only work as advertised when transaction costs are zero. In fact, markets are effective in discovering efficient transactions.[34]

5 THE TRAGEDY OF THE ANTI-MARKET

Liberalizing spectrum policy clears the path for myriad Nextels—not by special waivers, but by general policy. This empowers competitive spectrum owners to experiment with alternative network architectures or access models. It also permits governments to evaluate, with economic data gleaned from actual transactions, whether particular forms of spectrum access need to be subsidized. Just as a public park is best provided when the costs of the park are known and competitive alternatives permitted, exclusive spectrum ownership facilitates efficiency.

Some regulatory regimes are liberalizing. Countries such as Australia, New Zealand, Guatemala and El Salvador instituted sweeping reforms in the 1980s and 1990s, radically advancing the distribution of exclusive spectrum rights.[35] The United Kingdom has recently adopted a framework for simultaneously eliminating license restrictions and expanding the bandwidth allocated to such liberal licenses, aiming to allocate about 70% of spectrum under 3 GHz in such a manner by 2010.

Yet, the U.S. framework continues to allocate spectrum case-by-case. Since December 2002, for instance, the FCC has been enmeshed in a rule making to regulate TV band "white space." The policy would impose rules determining how unlicensed devices and broadcast stations co-exist. An alternative means of organizing shared use would be to issue TV band overlay rights giving new licensees full flexibility subject to interference protection for incumbents. This would delegate the creation of an access regime to competitive owners.

Sen. Larry Pressler (R-SD), then Chairman of the Senate Commerce Committee, proposed this solution in May 1996.[36] It was opposed by a wide range of political interests, including TV broadcasters. Regulators today simply ignore the licensed overlay as an alternative regime choice.

Much as in the 1990s, when the FCC allocated 30 MHz for unlicensed PCS (U-PCS). Apple Computer then argued that wireless LANs were in need of additional spectrum. Without considering the option that Apple acquire spectrum rights and configure them for LAN services, the FCC mandated a spectrum set-aside, imposed standards (including listen-before-talk), and set power limits. Yet, virtually no use has been made of the bands. Meanwhile, adjacent licensed PCS bands host intense traffic. The 30 MHz squandered on U-PCS would provide billions in annual consumer surplus gains were PCS operators able to acquire them.[37]

Apple suffers no penalty from the misallocation. This lack of accountability is a "tragedy of the anti-market." The future is unknowable, and the value of rival technologies, each with its own optimal mode for organizing spectrum access, is uncertain. Society loses the benefits of market competition when it socializes risky deployments of radio spectrum.

Examples abound. In the Upper 700 MHz band, guard bands intended to protect public safety operators were auctioned, but with restrictive use rules—such as a prohibition on cellular architecture—that effectively restricted use to the private wireless market (internal business communications). Auctioning the band and allowing private band managers to organize the band was seen as an innovation at the time.[38] Indeed, if the FCC had been correct in predicting the need for additional private wireless spectrum, then private band managers would have been a tool to deploy that spectrum efficiently. But the FCC was wrong in its prediction. Alternative commercial solutions, including Nextel's push to talk feature, greatly diminished the demand for private wireless spectrum. The band is now virtually worthless,[39] and enmeshed in yet another FCC allocation (or reallocation) process.[40]

Currently, the FCC's allocation of the 3650-3700 MHz has prevented through the delay of the regulatory process any U.S. use of the most popular international band for WiMAX services, touted as the natural extension of Wi-Fi local area networks (LANs) to wide area networks (WANs)—or "WiFi on steroids." This is in stark contrast to the use of the band by the rest of the world. The 3.5 GHz band represents over 40% of broadband equipment sales world wide in a market forecast to grow from $1 billion in 2005 to $2 billion in 2010.[41] Virtually none of those sales in the 3.5 GHz band to date have been in the US.

The 3650-3700 MHz band historically was used for satellite communications, but is caught in an ongoing FCC reorganization. Three exclusion zones for incumbent satellite earth stations will remain, with the rest of the band devoted to non-exclusive licensed users, with technical requirements that limit the use to communications with base stations. Though technically licensed, there is no exclusion. The FCC is set to create a licensed commons.[42]

By creating a commons in this band, the FCC makes many choices about how the band will, and will not, be used. Valuable technologies are excluded because companies will not invest when they cannot capture the benefits of their investments. Without the ability to exclude, a broadband service provider that would deploy a WiMax system cannot guarantee quality of service. Jerry Brito of George Mason University summarizes the problem created by the 3650-6700 MHz allocation:

> In effect, then, choosing a commons allocation over an exclusive licensed allocation—which can guarantee a certain quality of service—is a trade-off between a service that can consistently provide latency-sensitive services and one that is precluded from doing so. It is also a trade-off between rural and metropolitan wireless data services. One reason is that, as some contend, it might be impossible to effectively use a commons for wireless high-speed data in a congested metropolitan area. More importantly, however, while rural consumers might be willing to tolerate the inconvenience of slower speeds and a lower quality of service, metropolitan WISPs must compete against the incumbent highspeed data providers—cable and DSL—which do guarantee a high quality of service standard to their customers.[43]

Other problems are also created. Without property rights in the spectrum, an agreement on the level of protection afforded the incumbent satellite earth stations will be worked out in the political arena. The likelihood of an economically efficient outcome is small. The incumbent operators have every incentive to create the most exclusionary zone possible because anything less may cause them harm, but they are not able to benefit from any of the gains created by a smaller exclusion zone. Likewise, the non-exclusive licensees of the band have every incentive to argue for the smallest exclusion zone possible—thus maximizing spectrum available to them—regardless of any potential harm that might cause the satellite incumbents. In the "command-and-control" structure used to allocate this band as a licensed commons, the boundary of the exclusion zone will be decided by the FCC without any market data to inform its decision.[44]

Device manufacturers also loose the incentive to create devices that efficiently use spectrum. More efficient devices that embody more sophisticated technologies are likely to cost more. Purchasers of those more efficient devices have no incentive to pay the additional costs if doing so largely benefits other users of the band.[45] This position is recognized by some equipment manufacturers who commented in this proceeding.[46] They propose that in the markets were interference is most likely, the FCC modify its rules.

> [I]n large urban areas where contention is likely, Petitioners propose that the FCC modify the new rules to prescribe exclusive licensed use in the Top 50 Metropolitan Statistical Areas ("MSAs"). … Exclusive licensing will foster the most efficient use of spectrum in these markets. It will solve "tragedy of the commons" problems, promote optimal quality of service, and create strong business investment certainty – thereby best fostering long range, wireless broadband deployment in these more crowded areas.[47]

6 TV BAND REALLOCATION IN THE UNITED STATES

The policy quagmire in the U.S. TV Band illustrates the formidable political challenges to liberalization. Proposals to effectively privatize the TV band, and other productive radio spectrum, were advanced in 1996 by a leading U.S. Senator, and in 2002 by two prominent FCC policy analysts.[48]

But all forward momentum in this direction ceased in 2002, when the FCC issued its SPTF Report. Immediately thereafter it issued a Notice of Inquiry[49] which asked for public comment on how it should craft rules to allow unlicensed devices to access the TV band spectrum, an idea put forth by companies such as Microsoft, Intel, and Cisco, as well as by some foundations[50] and academics.[51]

The contrasting methods for allocating radio spectrum is vividly made here, even if the context (and policy margins) differ slightly from the analog-digital technology transitions made under opposing sets of resource rules. Under the unlicensed approach, the state must decide how to optimally share radio bandwidth. Current TV station broadcasters (today transmitting analog and digital broadcasts, scheduled to deliver just digital broadcasts after February 2009) are to be given priority, and—at the same instant—confined to the spectrum spaces delineated by regulators. Manufacturers of unlicensed devices are to make radios that conform to FCC specifications, meaning that they do not "interfere" with TV broadcasts, nor pose an undue threat to other unlicensed device use. These considerations will result in power limits and technology restrictions imposed by FCC administrative order.

The spectrum market alternative is to delegate such decisions to actual property owners. If we confine our analysis to just the 294 MHz that will continue to be frozen in the TV Band Allocation of 1939-1953,[52] the liberal approach would then be to issue overlay rights to competitive parties. For instance, five overlays could be created, allocating about 59 MHz to each, and assigned by competitive bid. Rights for new "spectrum owners" would include complete flexibility for in-band uses, subject to the rights of incumbent TV stations to broadcast. These contours could be adjudicated at low cost via existing regulatory criteria or, more promisingly, via binding arbitration, including rules which combined ownership shares (in overlays and adjacent, in-band stations) according to third-party valuations. In fact, the overlay rights issued to PCS licenses in the 1990s all contained substantial incumbency rights, which were successfully resolved without years of administrative combat—once the process moved from the delays imposed by "public interest" spectrum allocation to business deals between well-defined assets.[53]

Creating property rights in the TV bands and allowing markets to organize the use of those bands is the efficient, welfare enhancing policy solution. There are many competing uses for the TV bands and if the FCC is to continue its "command-and-control" approach to managing the band it will have to divine the winners and losers among them.

How might a market more efficiently organize the TV band? One option, excluded by the FCC's rigid digital television transmission licenses, would be to relocate digital television transmitting stations such so that they all transmit from a common point in each market. Co-location greatly reduces reception conflicts and allows a given number of broadcasts to consume much less radio spectrum, freeing bandwidth for other productive uses. These include "open access" regimes developed on frequencies dedicated by equipment manufacturers or service providers, rather than by regulatory fiat. With property rights in the TV band distributed to competitive firms, including broadcasters, reorganization would create gains from trade for all participants, benefiting incumbents and entrants alike.

This solution is a virtual impossibility through the political bargaining process embedded in the "command-and-control" regime. Here parties petition the regulator for their preferred outcome, investing in political influence but avoiding the assumption of economic risk associated with asset ownership. Methods for organizing spectrum use can be imposed, through the state, for expected financial gain, with costs imposed on third parties. Apple's petition for unlicensed PCS spectrum wasted billions in social opportunities, but cost its advocates next to nothing.

Imposing "white space" sharing rules on the TV band extends the "command-and-control" of broadcast spectrum allocations to yet another generation of technology. U.S. regulators do not appear concerned with marketplace evidence of the cost-benefit trade-offs, a product of the ill-defined property rights inherent in central planning decisions. Yet, there is much to suggest that additional unlicensed allocations will not produce significant social gains.

Even at a price of zero, there is little evidence that substantial excess demand exists in unlicensed spectrum allocations. For example, municipal Wi-Fi systems appear little constrained by the bandwidth limitations of unlicensed spectrum.[54] Ofcom, the U.K. regulator, recently observed that the 300 MHz of frequencies authorized for unlicensed use in the 1990s are only lightly used, concluding that little demand exists for additional license-exempt allocations over the next few years.[55] In the U.S., no congestion—and therefore demand for additional spectrum—has been reported for WiFi hotspots, public or private.[56] This is consistent with the experience in South Korea, thought to feature the densest deployments of public Wi-Fi hotspots in the world.[57] South Korea's Wi-Fi nodes operate entirely on the 2.4 GHz band; the additional 1990s allocations for unlicensed devices made elsewhere were not undertaken in South Korea.

Yet, the more fundamental advantage of liberal property rights as an allocation tool is that it encompasses and facilitates the further use of spectrum "commons." To the degree that private markets do not provide bandwidth for low-power devices found to be efficiently provided in access regimes resembling the license-exempt model, private firms, non-profit corporations, or government agencies are free—in a spectrum market—to make investments in bandwidth to remedy the shortfall.

The use of private property rights brings transparency, revealing the opportunity costs of the options available. Governments can buy spectrum rights if equipment manufacturers such as Apple or Intel do not. But first, legal rules must create the conditions for a market, so that each of these parties—and their competitors—gain the chance to shop.

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1 The specific standard is known as AMPS (Advanced Mobile Phone System).

2 FCC (2006b).

3 Hazlett & Munoz (2004). See also, Hazlett (2001b).

[4] Coase (1959).

[5] U.S. Congress (1997); Rosston & Hazlett (2001).

[6] Where potential conflicts do not materialize, or do not pose a significant threat to productive use of resources, "open access" is efficient. The cost of defining and enforcing rules for organizing resource use must, to be efficient, be outweighed by the benefits associated with such rules. See Demsetz (1967); Lueck & Miceli (forthcoming, 2007).

[7] In the U.S., the approval process for unlicensed devices imposes emission limits and technical standards "designed to ensure that there is a low probability that these unlicensed devices will cause harmful interference to other users of the radio spectrum." Carter et al (2003), p. 4.

[8] Carter et al (2003), p. 5.

[9] Hatfield & Weiser (2006).

[10] SPTF Report, p. 5.

[11] SPTF Report, p. 38.

[12] We recognize that the historical distribution of rights is important both politically and economically. The manner in which rights are initially established often implicate rent-seeking costs in the past and in the future, e.g. That is a different discussion, however.

[13] New York City routinely sells "slices" of Central Park by franchising private concessions. It permits restaurant owners, e.g., to enjoy exclusive rights for a fee. These revenues help offset the cost of maintaining the public park. The ability to reasonably evaluate trade-offs under a regime of exclusive ownership rights drives efficiencies across a wide swath of activities, supporting provision of public goods.

[14] See, generally, Lueck & Miceli (2006).

[15] "Common interest tragedies" result in inefficient under-use or over-use of a resource. See Fennell (2004), Hazlett (2005).

[16] This was Ronald Coase's (1959) intuition regarding the spectrum allocation system. Further research has supported this view. These include simply blocking new technologies from competing with existing ones. See the Section entitled "Silence of the Entrants" in Hazlett (2001a).

[17] Eric A. Taub, *The Big Picture On Digital TV: It's Still Fuzzy*, NY TIMES (Sept. 12, 2002); http://tech2.nytimes.com/mem/technology/techreview.html?_r=1&res=9801E0D61531F931A2575AC0A9649C8B63&oref=slogin. The revenue statistic assumes average U.S. sales prices are equivalent to international prices, where 2004 sales of $48 billion accounted for 150 million sets. Tekla S. Perry, *Digital TV's 100-Meter Dash*, IEEE SPECTRUM (June 2005), http://www.spectrum.ieee.org/jun05/1222.

[18] Total *worldwide* wireless LAN equipment sales total about $3 billion. See Hazlett (2006).

[19] Hazlett (2002b). The calculation assumes that about $300 is spent on each of the 10 million households that do not subscribe to a multi-channel video service.

[20] See Hazlett (2001b), Hazlett & Muñoz (2004).

[21] FCC (2002), ¶ 6.

[22] Leichtman Research Notes, 1Q 2005; http://www.leichtmanresearch.com/research/notes06_2005.pdf.

[23] Hazlett & Spitzer (2006).

[24] In contrast, note the extremely high valuation implicitly placed on additional cellular (liberal rights) spectrum by consumers, as estimated using an international dataset in Hazlett & Muñoz (2004).

[25] Bazelon (2006).

[26] Bazelon (2006).

[27] Kwerel & Williams (2002), p. 31 (footnote omitted).

[28] See Rosston & Hazlett (2001); Cave (2002); Hahn & Wallsten (2006).

[29] Kwerel & Williams (2002), p. 31.

[30] Carter et al (2003).

[31] See Hazlett (2001a).

[32] The firm was initially called Fleet Call.

[33] Hazlett (2003).

[34] An implication is that rights should be defined such that "transactions" are internalized. In its simplest form, if multiple parties have difficulty transacting, the optimal property rule then defines ownership across parcels. With a single owner, transactions are eliminated. The costs of internal organization, or a reduction in competitive market forces, may offset efficiency gains, it should be noted. See Demsetz (2003).

[35] For a description of these reforms, see Hazlett (2004).

[36] The senior author assisted in the preparation of this proposal. See Hazlett (2001a).

[37] See Hazlett & Muñoz (2004).

[38] Bazelon (2003). For an alternative perspective see Rosston (2003).

[39] Nextel gave back its licenses to the FCC as part of its grand spectrum swap, but those frequencies were not credited with any value. See FCC (2004), ¶ 324.

[40] FCC (2006a).

[41] Maravedis 2005, Exhibits 75 & 76.

[42] See generally, Brito (2006).

[43] *Id.*, p. 24 (footnote omitted).

[44] *Id.*, pp. 21-22.

[45] *Id.*, p. 27.

[46] Intel et al (2005).

[47] *Id.* p. v.

[48] Kwerel & Williams (2002). Evan Kwerel was then a Senior Economist in the Office of Plans and Policies at the FCC, while John Williams was a Senior Engineer in OPP.

[49] FCC (2002b).

[50] Snider (2006).

[51] Lehr (2004).

[52] Hazlett (2001b).

[53] Cramton et al (1998); Hazlett (2001a).

[54] "[A]ll the spectrum we need is already in play." Dewayne Hendricks, wireless ISP entrepreneur, quoted in THE ECONOMIST (Aug. 12, 2004).

[55] "[A] very large amount of spectrum has been recently reserved for licence-exempt use in the 5GHz band which is broadly unused at present." Ofcom, Spectrum Framework Review (Nov. 23, 2004), p. 26.

[56] Bazelon (2006).

[57] "*Half the World's Hotspots,"* BUS. WEEK (Apr. 28, 2003).