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RENT-SEEKING FOR SPECTRUM SHARING: THE 5.9 GHZ BAND ALLOCATION

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The battle over rules governing 5.9 GHz airwaves offers important lessons in both the creation of property rights and applied public choice. Set aside in 1999, the 75 MHz "Car Band" band was designated by the U.S. Federal Communications Commission (FCC) to support emerging vehicle telematics and computerized driving. Transportation regulators and automakers, including General Motors, Ford, and BMW, claimed this would efficiently promote road safety, fuel savings, and collision avoidance, as dedicated bandwidth would operate under a "spectrum commons" regime designed to favor such applications.[2] While anticipated services gradually developed, the 5.9 GHz band did not. Spectrum inputs outside the "Car Band" accommodated driving applications, while the general development of wireless networks shifted social priorities. Eventually, Internet services companies such as Comcast, Google and Microsoft claimed the 75 MHz allocation was wastefully large and that switching access rules to favor Wi-Fi would generate net benefits.[3] Suggested for possible reallocation by the

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[2] General Motors, Comment on FCC Proposed Rule for Use of the 5.850-5.925 GHz Band, ET Docket No. 19-138, at 1 (Mar. 9, 2020), https://www.fcc.gov/ecfs/file/download/DOC-5c309923c4400000-A.pdf?file_name=3-09-20%20GM%20FINAL.pdf; The BMW Group, Comment on FCC Proposed Rule for Use of the 5.850-5.925 GHz Band, ET Docket No. 19-138, at 2 (Mar. 9, 2020), https://www.fcc.gov/ecfs/file/download/DOC-5c306f31c0c0000A.pdf?file_name=BMW%20Submission%20ET%20Docket%20No.%2019-138%20(003).pdf; The Ford Motor Company, Comment on FCC Proposed Rule for Use of the 5.850-5.925 GHz Band, ET Docket No. 19-138, at 4-5 (Mar. 9, 2020), https://www.fcc.gov/ecfs/file/download/DOC-5c3026a3aa400000A.pdf?file_name=Ford%20Submission%20to%20FCC%20Mar%209%202020.pdf.

[3] Comcast Corporation, Comment on FCC Proposed Rule for Use of the

U.S. Department of Commerce since 2012, the FCC issued an order in 2020 to split the baby: 45 MHz of the band would be shifted to Wi-Fi, with 30 MHz remaining dedicated for Intelligent Transportation Systems. The FCC's 2020 "Cost Benefit Analysis" purports to quantify the trade-offs involved, but upon scrutiny fails to plausibly value Wi-Fi services or to even consider the relevant opportunity costs. The costly, delay-intensive and ad hoc policy process (whose costs are additionally ignored by the FCC) begs for further development of auction mechanisms to rationalize alternative rights assignments.

5.850-5.925 GHz Band, ET Docket No. 19-138, at 1 (Mar. 9, 2020), https://www.fcc.gov/ecfs/file/download/DOC-5c304fd803800000-A.pdf?file_name=Comcast%205.9%20GHz%20Comments%2003.09.2020.pdf; Microsoft Corporation, Comment on FCC Proposed Rule for Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band, ET Docket No. 13-49, at 1 (Jul. 7, 2016), https://www.fcc.gov/ecfs/file/download/DOC-55720df44b800000-A.pdf?file_name=Microsoft%205.9%20GHz%20Comments%20(AS%20FILED).pdf; *5.9 GHz: Best Opportunity for Better Wi-Fi Fast*, WIFIFORWARD (Jan. 23, 2020), http://wififorward.org/wp content/uploads/2019/08/WFF_5.9_Policy_Primer_Final.pdf.

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I. Introduction

Radio spectrum, the "invisible resource," is a valuable input into wireless services.[4] Two important strains of economic analysis converge in modern disputes over defining and allocating resource rights. First, public choice describes the process wherein rival economic agents act strategically to gain favorable political assignments.[5] This focuses on the social costs generated by winners and losers in contests involving wealth transfers.[6]

Second, "law and economics" literature has investigated how ownership of valuable resources evolves, impacting social efficiency. The argument, originally motivated by Ronald Coase's observations on regulating radio frequencies,[7] and then formalized by Harold Demsetz,[8] was seen to explain social mechanisms for internalizing externalities. In the absence of well-defined ownership rights, "considerable confusion" may reign, Coase augured,[9] and economic opportunities may be squandered.

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[4] HARVEY J. LEVIN, THE INVISIBLE RESOURCE: USE AND REGULATION OF THE RADIO SPECTRUM (Henry Jarrett et al. 1971).

[5] Lionel Orchard & Hugh Stretton, *Public Choice*, 21 CAMBRIDGE J. ECON. 409, 409 (1997).

[6] Gordon Tullock, *The Welfare Costs of Tariffs, Monopolies, and Theft*, 5 W. ECON. J. 224, 230 (1967); Ann O. Krueger, *The Political Economy of the Rent-Seeking Society*, 64 AM. ECON. REV. 291, 291 (1974).

[7] R.H. Coase, *The Federal Communications Commission*, 2 J. L. & ECON. 1, 26 (1959); *See also,* Ronald H. Coase, *The Problem of Social Cost*, 3 J. L. & ECON. 1, 1 (1960).

[8] Harold Demsetz, *Toward a Theory of Property Rights*, 57 AM. ECON. REV. 347, 349 (1967).

[9] Coase, *supra* note 7, at 14 ("We know from our ordinary experience that land can be allocated to land users without the need for government regulation by using the price mechanism. But if no property rights were created in land… it is clear that there would be considerable confusion and that the price mechanism could not work because there would not be any property rights that could be acquired.").

Both approaches have led economists,[10] lawyers,[11] and political scientists[12] to seek to understand how social costs are generated in the establishment of property rights, and to suggest that mechanism design should take account of the relevant social costs and benefits. Yet, it is characteristic of many administrative processes that decision-makers misperceive such trade-offs in favor of categorical approaches to rights creation.[13] This paper aims to investigate such behavior in important rights-creating activities in telecommunications. The inquiry encompasses the impact of rent-seeking by industry interests and considers how reforms promoting further use of established regulatory mechanisms could allow increased transparency and efficient demand revelation.

The specific policy competition investigated concerns rival claims for how to use frequencies at 5.9 GHz. In 1999, a 75 MHz band was set aside for Intelligent Transportation Systems (ITS) applications to be used by motor vehicles on roadways. Over time, however, contentious demands were made – notably by advocates of Wi-Fi services who argued that the airwaves in question should be reallocated to support wireless local area networks.[14] In November 2020, after nearly a decade of administrative process, the FCC ordered that 45 MHz of the band be switched to accommodate Wi-Fi.[15]

The decision included an analysis of costs and benefits, allowing some considerable transparency into the rationale driving the regulatory decision. This paper examines this process, the action taken, and the analysis done. It benefits from the interesting fact that the

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[10] Terry Anderson & P.J. Hill, *The Evolution of Property Rights: A Study of the American West,* 18 J.L. & ECON. 163, 163 (1975); Dean Lueck & Thomas Miceli, *Property Law*, 1 HANDBOOK OF L. AND ECON. 183, 186 (2007); Gary D. Libecap & James L. Smith, *The Economic Evolution of Petroleum Property Rights in the United States*, 31 J. LEGAL STUD. S589, S589 (2002); DAVID FRIEDMAN, LAW'S ORDER 8 (2001).

[11] RICHARD POSNER, ECONOMIC ANALYSIS OF LAW 46 (9th ed. 2014); Thomas W. Merrill & Henry E. Smith, *What Happened to Property in Law and Economics*?, 111 YALE L.J. 357, 359-360 (2001); Carol M. Rose, *The Several Futures of Property: Of Cyberspace and Folk Tales, Emission Trades and Ecosystems*, 83 MINN. L. REV. 129, 129 (1998); MICHAEL HELLER, THE GRIDLOCK ECONOMY (2008).

[12] ELINOR OSTROM, GOVERNING THE COMMONS (James E. Alt et al. eds.,1990).

[13] *See generally* Charles Wolf, *The Theory of Non-Market Failure*, 22 J.L. & ECON. 107, 107 (1979).

[14] Monica Alleven, *AT&T, T-Mobile Butt Heads with Comcast, Wi-Fi in 5.9 GHz Melee*, FIERCE WIRELESS (Apr. 29, 2020), https://www.fiercewireless.com/regulatory/at-t-t-mobile-butt-heads-comcast-wi-fi-5-9-ghz-melee [https://perma.cc/7FRH-KS92].

[15] FCC, 35 FCC Rcd. 13440, FCC MODERNIZES 5.9 GHZ BAND FOR WI-FI AND AUTO SAFETY (2020).

coalitions on both sides of this regulatory contest were competing for non-exclusive rights where the FCC, rather than winning bidders, would determine the use of the radio spectrum. That prompts a policy debriefing that considers how extending auctions, conducted in scores of spectrum allocations since 1994 and raising over $200 billion in government revenues, might bring further clarity to the social choices involved in choosing between alternative spectrum regimes.

I.1 Liberal Spectrum Licenses

U.S. law has formally denied private ownership in spectrum since the 1927 Radio Act.[16] Despite this legal constraint, substantial reforms have occurred via regulatory discretion in recent decades. In particular, the flexible-use licenses granted to mobile carriers, now covering approximately fifteen percent of prime frequency space[17] (below 6 GHz), are broadly permissive. Parties that acquire such liberal licenses, whether by auction from the FCC or via secondary market trades,[18] enjoy wide discretion to deploy the networks, devices, business models, content and applications of their choosing. These permits host the most economically valuable wireless services supplied, namely those providing voice and broadband Internet access via mobile platforms. Importantly, however, such uses are not mandated. The authorizations are analogous to private property rights in radio spectrum and allow competitive forces to determine how airwaves are utilized (and shared) as distinct from administrative allocation.[19]

To illustrate, the introduction of the iPhone on AT&T's mobile network in 2007 created considerable "interference" as existing subscribers jockeyed to access shared frequencies and base stations,

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[16] Thomas W. Hazlett, *The 1927 Radio Act As Pre-Emption of Common Law Property Rights*, 56 REV. INDUS. ORG. 17, 26 (2020).
[17] THOMAS W. HAZLETT, THE POLITICAL SPECTRUM: THE TUMULTUOUS LIBERATION OF WIRELESS TECHNOLOGY, FROM HERBERT HOOVER TO THE SMARTPHONE 32 (2017).
[18] The adoption of competitive bidding to assign FCC licenses required a 1 993 statute. Auctions began at the Commission in 1994 and have generated over $200 billion in licenses sales since. Private auctions, as in secondary market trading, have been observed since prior to the 1927 Radio Act when AM broadcast radio stations exchanged, and broadcasting rights went with the apparatus. Thomas W. Hazlett, *The Rationality of U.S. Regulation of the Broadcast Spectrum*, 33 J.L. & ECON. 133, 144, 169 (1990) (The adoption of competitive bidding to assign FCC licenses required a 1993 statute. Auctions began at the Commission in 1994 and have generated over $200 billion in licenses sales since. Private auctions, as in secondary market trading, have been observed since prior to the 1927 Radio Act when AM broadcast radio stations exchanged, and broadcasting rights went with the apparatus.).
[19] Thomas W. Hazlett & Evan Leo, *The Case for Liberal Spectrum Licenses: A Technical and Economic Analysis*, 26 BERKELEY TECH. L.J. 1037, 1037-1101 (2011).

competing with iPhone users commonly judged to be "spectrum hogs."[20] The flexible-use rights delegated to the carrier AT&T afforded them choices as to how to best coordinate conflicts and control congestion.[21]

A generation before, in contrast, regulators issued narrowly defined licenses tightly restricting what radio services could be delivered and then mandating how they were supplied.[22]This rationed scarce frequency spaces by administrative edict. If a technology like FM radio sought to displace AM radio, the innovation would have to be authorized by the FCC as being "in the public interest" – which determination could (and did) delay its adoption by thirty years.[23] This spectrum allocation system, dating to the 1927 Radio Act, was critiqued by Ronald Coase.[24]

While the system of centralized control was promoted so as to prevent "harmful interference," Coase pointed out the two-sided nature of the problem.[25] Rules protecting one service or technology from encroachment in the use of spectral inputs would simultaneously block – *interfere* with – the opportunity for new, competing uses.[26] The issue was how the system would evaluate the gains from favoring one spectrum use against the losses that accrued from blocking another, and then implement efficient choices by embracing the most productive outcomes. Government commissions seemed to have misunderstood the essential problem, as they were susceptible to industry capture and prone to restrict productive activity without proper knowledge of tradeoffs.[27]

While experts on spectrum allocation (and even the U.S. Supreme Court) have tended to see wireless access as a unique problem of "physical scarcity," Coase perceived it to be a vastly more general problem of *economic scarcity*.[28] As a thought experiment, he pondered whether rules limiting externalities in radio transmissions might be

[20] Fred Vogelstein, *Bad Connection: Inside the iPhone Network Meltdown*, WIRED (Jul. 19, 2010), https://www.wired.com/2010/07/ff-att-fail/ [https://perma.cc/ZQ23-YH5P].
[21] Thomas W. Hazlett, *A Short History of the Radio Explains the iPhone's Success*, HARV. BUS. REV. (June 29, 2017), https://hbr.org/2017/06/a-short-history-of-radio-explains-the-iphones-success [https://perma.cc/59TX-R9CN].
[22] Coase, *supra* note 7, at 6.
[23] HAZLETT, *supra* note 17, at 62-69.
[24] Coase, *supra* note 7, at 37.
[25] Thomas W. Hazlett et al., *Radio Spectrum and the Disruptive Clarity of Ronald Coase*, 54 J.L. & ECON. S125, S130-S131 (2011).
[26] *Id.*
[27] *Id.* at S125.
[28] Thomas W. Hazlett, *Physical Scarcity, Rent-Seeking, and the First Amendment,* 97 COLUM. L. REV. 905, 905-44 (1997).

more usefully crafted as property rights in frequencies issued to decentralized parties.[29] Such resource owners could then determine how to best use and share their rights, and how to resolve border disputes. His analysis was initially dismissed – Professor Harry Kalven, Jr., of the University of Chicago Law School, referred to it as "an insight more fundamental than we can use" –[30] but came to be widely persuasive.[31]

Yet regulators began – particularly, when authorizing cellular phone networks in the 1980s – to issue licenses granting "flexible use."[32] Instead of services, technologies, business models and network architecture being specified, licensees were given control over defined frequency spaces. This approach shifts the rights regime from state property (per administrative decisions) towards private property (where competition polices airwaves).[33]

In the Apple iPhone event, AT&T made the choice to introduce new sources of "interference" by hosting additional radio devices.[34] The AT&T network accommodated by concomitantly investing in extra capacity – additional cellular base stations, upgrading to 3G, 4G and then 5G technologies, and buying more mobile licenses to expand bandwidth available for radio access.[35] The carrier also optimized traffic flows by embedding such techniques as dynamic power control in handsets (wherein cellphones continuously adjust to the lowest power levels maintaining links to base stations, economizing on airwave spillovers), and rationing access to airwaves via subscription prices (charging more for additional data usage while reducing fees for low-bandwidth apps like texting and for non-congesting uses like "off-peak" voice).[36]

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[29] Hazlett et al., *supra* note 25, at S128-S129.

[30] Harry Kalven, Jr., *Broadcasting, Public Policy and The First Amendment*, 10 J.L. & ECON. 15, 30 (1967).

[31] *See* Thomas W. Hazlett, *Ronald Coase* , *in* PIONEERS IN LAW AND ECONOMICS 2 (Lloyd R. Cohen et al. ed., 2009) (the ideas formed the basis of the economic research cited when Coase was awarded the Nobel Prize in Economics in 1991.).

[32] Hazlett, *supra* note 17, at 212-235.

[33] This shift in the regime obtains once spectrum allocations have been made. The underlying choice of regimes remains subject to administrative control. That process, undertaken by a regulatory commission under a "public interest" standard, is central to the topic of this paper.

[34] *See generally* Vogelstein, *supra* note 20; s*ee generally* Hazlett, *supra* note 21.

[35] Chris Sambar, *Why We're Expanding One of the Country's Largest Fiber Networks – and Why That Matters to You*, AT&T (Aug. 2, 2022), https://about.att.com/innovationblog/2022/sambar-fiber-expansion.html [https://perma.cc/C5UL-YAY6].

[36] Thomas W. Hazlett & Sarah Oh, *Exactitude in Defining Rights: Radio*

Each network acts as a platform sponsor, undertaking to encourage an ecosystem supplying complements that include devices, network infrastructure, content and applications. The Apple iPhone was itself a major investment for mobile carriers. Due to the exceptional popularity of the iPhone, that price has proven negative – the carriers pay the manufacturer, Apple, for making phones that access the network –[37] even as Apple must secure spectrum rights by contract (or else iPhones would have little value to buyers).

Carriers acquiring exclusive spectrum rights internalize both the benefits of additional interference (subscribers pay more for valuable new services) and its costs (traffic congestion leading to degraded network performance tend to reduce demand).[38]The same internalization applies to measures for interference abatement. Incentives for efficiency are supported by liberal wireless licenses, which rely on competition between wireless operators to iterate towards optimal methods of conflict resolution. One obvious pattern is that national networks develop. While 51 regional licenses were issued for the PCS (2G) "B" licenses auctioned by the FCC in 1994, all of them were soon owned or controlled by one firm (Sprint).[39] This aggregation (which eliminates border disputes by eliminating borders) has been seen consistently in mobile markets, even as license coverage has become even more fragmented (commonly consisting of 416 "partial

Spectrum and the "Harmful Interference" Conundrum, 28 BERKELEY TECH. L.J. 227, 274 (2013).

[37] Fred Vogelstein, *The Untold Story: How the iPhone Blew Up the Wireless Industry*, WIRED (Jan. 9, 2008), https://www.wired.com/2008/01/ff-iphone/ [https://perma.cc/FY6P-DMEH] (Not only did carriers pay a high price for Apple's products, heavily subsidizing customer adoption, but they ceded control over software and applications (and what became the App Store) to Apple. "In return for five years of exclusivity, roughly 10 percent of iPhone sales in AT&T stores, and a thin slice of Apple's iTunes revenue, AT&T had granted [Apple CEO Steve] Jobs unprecedented power. He had cajoled AT&T into spending millions of dollars and thousands of man-hours to create a new feature, so-called visual voicemail, and to reinvent the time-consuming in-store sign-up process. He'd also wrangled a unique revenue-sharing arrangement, garnering roughly $10 a month from every iPhone customer's AT&T bill. On top of all that, Apple retained complete control over the design, manufacturing, and marketing of the iPhone."); Sam Gustin, *Verizon Wireless Finally Gets Apple's iPhone*, WIRED (Jan. 11, 2011), https://www.wired.com/2011/01/verizon-iphone-launch/ [https://perma.cc/22HY-TTFJ].

[38] Thomas W. Hazlett, *Assigning Property Rights to Radio Spectrum Users: Why Did FCC License Auctions Take 67 Years?*, 41 J.L. & ECON. 529, 570 (1998).

[39] Thomas W. Hazlett, *U.S. Wireless License Auctions*, AUSTRALIAN COMPETITION & CONSUMER COMM'N, July 14, 2009, at 8-9.

economic areas" in recent FCC auctions).[40] Overall, such market configurations have been judged a great success by policy makers.[41]

I.2 Spectrum Allocations for Non-Exclusive Rights

Unlicensed bands offer regulators another path for spectrum allocation by issuing non-exclusive access rights. Often described as enabling "spectrum commons,"[42] the approach is actually a *state property* regime in the taxonomy of law and economics.[43] Elinor Ostrom's famous book, GOVERNING THE COMMONS,[44] demonstrates how common pool assets like pastures, forests, water, or fishing grounds are managed. Commons owners, often users of a jointly held resource, conserve value by enforcing rules to prevent over-consumption.[45] Unlicensed spectrum resources, conversely, are governed by communications regulators.[46] Rules may set maximum power for emissions, require certain permissions for frequency use, and restrict technologies, business models, or network architecture.[47] Non-

[40] Hazlett & Oh, *supra* note 36, at 311.
[41] FED. COMMC'N COMM'N, NATIONAL BROADBAND PLAN 79 (2010) ("Flexibility of use enables markets in spectrum, allowing innovation and capital formation to occur with greater efficiency. More flexible spectrum rights will help ensure that spectrum moves to more productive uses, including mobile broadband, through voluntary market mechanisms.").
[42] FED. COMMC'N COMM'N, SPECTRUM POLICY TASK FORCE REPORT, ET DOCKET NO. 02-135, at 33-34 (2002).
[43] Lueck & Miceli, *supra* note 10, at 190 (The four main regimes are: Open Access, Private Property, Common Property and State Property. With private and common property, private sector agents exercise control, while state property access rules are set by government authorities. The key element in each is where the right to exclude is vested.).
[44] OSTROM, *supra* note 12, at 1.
[45] Armen A. Alchian & Harold Demsetz, *Production, Information Costs, and Economic Organization*, 62 AM. ECON. REV. 777, 788 (1972) (Ostrom's commons are generally structured this way. However, perhaps the most widely used "commons" ownership institution occurs in the creation of joint stock companies. Common shareholders supply risk capital, while managers make decisions over how to profitably use resources for producing goods consumed by others. Use of the firm's property is policed by governance rules holding managers accountable to shareholders, as well as by competition for managers.).
[46] *Unlicensed Spectrum,* WIFI ALLIANCE (Sept. 13, 2022, at 7:24pm), https://www.wi-fi.org/discover-wi-fi/unlicensed-spectrum [https://perma.cc/L3P2-7QFN].
[47] MAHBUBUR RAHMAN & ABUSAYEED SAIFULLAH, A COMPREHENSIVE SURVEY ON NETWORKING OVER TV WHITE SPACES, IN PERVASIVE AND MOBILE COMPUTING 59, 59 (2019) (In some cases, commercial uses are forbidden (as opposed to self-provisioning, exemplified by a local area wireless connection supplied by a homeowner's wi-fi hotspot). In other cases, indoor applications are restricted to different power levels than permitted for outdoor applications. In others, mobile devices are subject to additional restrictions than fixed devices. Finally, radios may be mandated

exclusive access is then permitted for conforming wireless applications.[48] *Governance* rules, as opposed to *exclusive* rights, impose ex ante rules to mitigate conflicts and externalities.[49] Neither governance nor exclusion is a frictionless path to optimal resource deployment in all situations; tradeoffs are evident.

A central confusion, owing to the legacy of the 1968 Garrett Hardin article, "Tragedy of the Commons," in *Science*, is that the singular regulatory objective in unlicensed bands is to guard against resource dissipation.[50] Where destructive overuse is found, the regime is pronounced a failure; where such apparent overuse is found lacking, it is presumed to be successful.[51] But the absence of visible conflict ("static interference" in wireless markets) is misinterpreted. Indeed, a

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to coordinate with other radios by scanning or checking databases for permission to use a particular frequency. The latter is embedded in such services as television white space devices (TVWSDs) and Citizens Broadband Radio Services (CBRS).); MARIA MASSARO & FERNANDO BELTRAN, WILL 5G LEAD TO MORE SPECTRUM SHARING? DISCUSSING RECENT DEVELOPMENTS OF THE LSA AND THE CBRS SPECTRUM SHARING FRAMEWORKS, IN TELECOMMUNICATIONS POLICY 44, 44 (2020); *see* E.K. Jett, *Phone Me by Air*, SATURDAY EVENING POST, July 28, 1945, at 16 (Methods as "listen before talk" or "dynamic frequency adjustment" differ in cost and effectiveness. LBT, e.g., draws on batteries and reduces radio throughput, all else equal. - It is often thought to be a new technology, but it dates back to at least World War II).

[48] CB and R/C License by Rule, 48 Fed. Reg. 24882 (Jun. 3, 1983) (Type acceptance" was a rule switch adopted in a 1982 congressional statute, and pertained to the regulation of CB radio operators and radio control (R/C) users. The FCC later explained the logic: Individualized R/C and CB licensing is not used to assign specific frequencies, output power or hours of operation. All R/C and CB licensees are authorized to operate on legal R/C and CB frequencies with legal power at any time of the day. Applicants are not required to show financial or technical qualifications… Spectrum management in the R/C and CB radio services is accomplished by way of type acceptance and operating rules, rather than licensing. R/C and CB transmitters are type accepted to assure that they are operated on legal frequencies with legal power. Frequency assignments, power limitations and antenna height restrictions are determined by rule making, not by licensing."); ADMIN. CONF. U.S., Appendix B (2015) (explaining the transaction costs driving such changes in FCC licensing.).

[49] Henry E. Smith, *Exclusion versus Governance: Two Strategies for Delineating Property Rights*, J. LEGAL STUD. S453, S456 (2002) (This is similar to the legal distinction between *in personam* rules, which define how users may access resources, and *in rem* rights, which define ownership claims over resources themselves. In the latter, owners determine how to share beneficial uses, while in the former case coordination is supplied by rules formed and interpreted by third-parties (say, regulators or judges)).

[50] Garrett Hardin, *The Tragedy of the Commons*, AM. ASS'N. FOR ADVANCEMENT SCIENCE., Dec. 13, 1968, at 1243.

[51] Douglas C. Sicker et. al., *Examining the Wireless Commons*, TELECOMM. POL'Y. RSCH. CONF. (2006).

rule regime that locks out all use of a potentially productive band is definitionally inefficient. Other comparisons feature more subtle tradeoffs, but the level of observed conflict is not the appropriate metric for judging success. As Coase observed:

"It is sometimes implied that the aim of regulation in the radio industry should be to minimize interference. But this would be wrong. The aim should be to maximize output."[52]

The economically rational test of public policy compares the welfare outcome of one regime to that of the next best option. Spectrum resource dissipation can result from a regime that permits relatively too much entry, or too little.[53] And the value of the usage (or traffic) reflects quality enhancements in outputs that may (or may not) come from investments in complementary inputs, including technology upgrades and network infrastructure.[54] Hence, some unlicensed regimes have imposed coordination rules that effectively allowed too little economic activity, as in Unlicensed PCS (1994), the 3650 GHz rule making (2005), and TV White Spaces (2008).[55] These excessively prevented productive spectrum employments relative to alternative rights regimes, but the "tragedy" was not to be found in resource dissipation by overuse.[56]

The paradigmatic application to emerge in unlicensed bands is Wi-Fi, the wireless local area network (WLAN) technology hosted on Industrial, Scientific and Medical (ISM) bands, U-NII (unlicensed National Information Instructure) bands, and CBRS channels (Citizens' Band Radio Services).[57] Wi-Fi links generally connect devices in close proximity, complementing wide area networks (WANs) supplied by mobile carriers and broadband Internet Service Providers (ISPs).[58] In home or office environments, a low-power Wi-Fi router

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[52] Coase, *supra* note 7, at 27.
[53] Lee Anne Fennell, *Common Interest Tragedies*, 98 NW. L. REV. 907, 937 (2004).
[54] *See generally id.*
[55] Regulations for Unlicensed Personal Communication Services, 47 Fed. Reg. 15 (Aug. 8, 1994); *3650-3700 MHz Radio Service,* FED. COMMC'N COMM'N (Sept. 13, 2022 at 8:34 PM), https://www.fcc.gov/wireless/bureau-divisions/mobility-division/3650-3700-mhz-radio-service [https://perma.cc/UVD9-LCWW]; Unlicensed White Space Device Operations in Television Bands, 87 Fed. Reg. 54,901 (Sept. 8, 2022).
[56] Thomas W. Hazlett & Michael Honig, *Valuing Spectrum Allocations*, 23 MICH. TELECOMM. & TECH. L. REV. 85-86, 93 (2016).
[57] Michael J. Marcus, *Wi-Fi and Bluetooth: The Path from Carter and Reagan-era Faith in Deregulation to Widespread Products Impacting our World*, 11 INFO 19 (2009); Vic Hayes & Wolter Lemstra, *License-exempt: The Emergence of Wi-Fi*, 11 INFO 57 (2009).
[58] *What is Wi-Fi?*, GEEKS FOR GEEKS (Dec. 28, 2021), https://www.geeksforgeeks.org/what-is-wi-fiwireless-fidelity/ [https://perma.cc/HK6T-7XZR].

relays the connection to nearby users using unlicensed spectrum, much as "cordless phones" extended telephone networks in the 1990s. Even shorter device-to-device connections are similarly made via Bluetooth technology. Unlicensed allocations enforce power limits and other rules to favor WLAN applications, whereas spectrum use rights tend to be vested in specific parties when regulators presume that wide area applications like cellular telephony is the most socially valuable deployment.[59] This reflects the transaction costs of coordinating local as opposed to distant usage, although other economic and political drivers also impose on regulatory outcomes.

II. The 5.9 GHz Band Allocation Debate

The distinct approaches adopted within the spectrum allocation system have provoked disagreement over whether private property rights, as per liberal licenses, are made obsolete by unlicensed allocations.[60] In these arguments, little has generally been made of the important fact that many of the most intense spectrum allocation rivalries have developed between competing *non-exclusive* designations.[61]

One such controversy is the tussle over the 5.9 GHz band, frequencies set aside for auto telematics and informatics in the last century. About a decade later, however, Wi-Fi champions argued that the set-aside would be better used to support WLAN access to the

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[59] *Id.*; FED. COMMC'N COMM'N INT'L BUREAU OF STRATEGIC ANALYSIS AND NEGOT. DIV., REVIEW OF SPECTRUM MANAGEMENT PRACTICES (2002)..

[60] Thomas W. Hazlett, *The Wireless Craze, the Unlimited Bandwidth Myth, the Spectrum Auction Faux Pas, and the Punchline to Ronald Coase's 'Big Joke': An Essay on Airwave Allocation Policy*, 15 HARV. J.L. & TECH. 335 (2001); DAVID FARBER & GERALD FAULHABER, SPECTRUM MANAGEMENT: PROPERTY RIGHTS, MARKETS AND THE COMMONS 193 (Faith Cranor & Wildman eds., 2003); Gregory Staple & Kevin Werbach, *The End of Spectrum Scarcity,* IEEE SPECTRUM (Mar. 1, 2004), https://spectrum.ieee.org/the-end-of-spectrum-scarcity [https://perma.cc/B6UX-P4GX]; Thomas W. Hazlett & Matthew L. Spitzer, *Advanced Wireless Technologies and Public Policy*, 79 S. CAL. L. Rev. 595, 595 (2006); Thomas W. Hazlett & Evan Leo, *The Case for Liberal Spectrum Licenses: A Technical and Economic Analysis*, 26 BERKELEY TECH. L.J. 1037, 1037 (2011); PRESIDENT'S COUNCIL OF ADVISORS ON SCIENCE AND TECHNOLOGY, REPORT TO THE PRESIDENT: REALIZING THE FULL POTENTIAL OF GOVERNMENT-HELD SPECTRUM TO SPUR ECONOMIC GROWTH (2012) (In our discussion in this paper, we include "light licensing" or "licensed by rule" as "unlicensed" since those regimes feature non-exclusive access to radio spectrums (while additional rules may be imposed on users, such as database registration).).

[61] *Contra* Mark M. Bykowsky et al., *A Market-Based Approach to Establishing Licensing Rules: Licensed Versus Unlicensed Use of Spectrum* 11 (Office of Strategic Plan. & Pol'y Analysis, Working Paper No. 43, 2008); HAZLETT, *supra* note 17, at 264.

Internet.[62] Opportunity costs were claimed to be low, given little utilization of the spectrum for the planned applications, while the economic benefits high, given the emerging popularity of Wi-Fi service.[63] Advocates for automobile companies and their emerging "connected car" applications (including the U.S. Department of Transportation) sharply disagreed, casting efforts to classify new wireless uses as a threat to the "mission critical" applications, invoking life-threatening consequences.[64] Because the spectrum allocation process relies on an administrative determination by the FCC, decision-makers lack market bids (or prices) to quantify trade-offs.[65] Rent-seeking rivalries arise in the vacuum.

The ensuing regulatory process carries important implications for resource allocation. Fortunately, the extant competition offers the opportunity to observe economic and political behavior where the rent-seeking dynamic converges with the evolution of property rights.

II.1 Regulatory Background

In 1991, Congress enacted the Intermodal Surface Transportation Safety Act. It funded research in automatic car safety systems, and the Department of Transportation proceeded to develop a prototype of an autonomous driving vehicle.[66] The approach, however, relied on extensive (fixed) roadside infrastructure.[67] A more decentralized pathway, based on car-based computers, was later adopted by companies. To facilitate that more promising approach, a trade association for such interests asked the FCC, in 1997, to create a "Car Band" to support connected vehicles.[68] The plan was to have a

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[62] FED. COMMC'N COMM'N, ET DOCKET19-138, MODERNIZING THE 5.9 GHZ BAND, FIRST REPORT AND ORDER (2020).

[63] *Id.*

[64] *20 Questions About Connected Vehicles*, OFFICE OF THE ASSISTANT SECRETARY FOR RESEARCH AND TECHNOLOGY (Sept. 13, 2022, at 9:16 PM), https://www.its.dot.gov/cv_basics/cv_basics_20qs.htm [https://perma.cc/TY65-Y4LQ].

[65] While auctions have been held by the FCC for (some) licenses distributed since 1994, the underlying spectrum allocation – determining how rights are defined and enabling frequencies to be used – is conducted in the traditional "public interest" evaluation under the 1927 Radio Act. At the allocation stage, the administrative choice invites lobbying by interested parties and their coalition partners. Such decisions are made prior to employment of "arm's length" competitive bidding mechanisms.

[66] Intermodal Surface Transportation Efficiency Act of 1991, H.R. 2950, 102nd Cong. (1991).

[67] *Id.*

[68] Michael Calabrese, *Spectrum Silos to Gigabit Wi-Fi: Sharing the 5.9 GHz 'Car Band'*, OPEN TECH. INST. (Jan. 2016), https://static.newamerica.org/attachments/12279-spectrum-silos-to-gigabit-wi-

regulatory set-aside of radio frequencies to host an IEEE 802.11 standard for connected vehicles.[69] In 1998, additional legislation was passed directing the Federal Communications Commission to consider making spectrum available for "intelligent transportation systems [ITS], including spectrum for the dedicated short-range [DSRC] vehicle-to-wayside wireless standard."[70] In 1999, the FCC responded, allocating 75 MHz – 5850 to 5925 MHz – in the so-called 5.9 GHz Band.[71]

The allocation for DSRC was traditional top-down spectrum policy. The FCC determined the best use of a frequency, excluding alternatives, and mandated usage conforming to this design.[72] The application permitted was for a V2V and V2I communications. A specific band plan was authorized, and channels were fixed (see Figure 1). There was to be a reserve band of 5 MHz, then seven 10 MHz channels, one with higher allowable power emitted and one dedicated to signals controlling wireless traffic congestion.[73]

Spectrum rights were non-exclusive, and appeared to regulators to eliminate competitive bidding (auctions) as a rights assignment tool.[74] While the car makers petitioning for the spectrum allocation clearly expected to benefit from the planned services designed to complement their products, no private entity could exercise exclusionary rights or deviate from regulatory standards.[75] A reallocation, allowing the frequencies to be used in novel ways, would require a new administrative rulemaking.

The FCC's official rationale was simply stated:

fi/OTI_5.9ghz_web.5de7495517f3416cae27fe811f0f985b.pdf [https://perma.cc/49K6-XUN3]; ARINC, SPECTRUM REQUIREMENTS FOR DEDICATED SHORT RANGE COMMUNICATIONS (DSRC): PUBLIC SAFETY AND COMMERCIAL APPLICATIONS (1996).

[69] The Institute of Electrical and Electronics Engineers (IEEE) is an international professional organization engaged in standard setting.

[70] Calabrese, *supra* note 68, at 12.

[71] FED. COMM'N COMM'N, ET DOCKET NO. 98-95, AMENDMENT OF PARTS 2 AND 90 OF THE COMMISSION'S RULES TO ALLOCATE THE 5.850-5.925 GHZ BAND TO THE MOBILE SERVICE FOR DEDICATED SHORT-RANGE COMMUNICATIONS OF INTELLIGENT TRANSPORTATION SERVICES (1999).

[72] *See* FED. COMMC'N COMM'N, ET DOCKET NO. 98-95, AMENDMENT OF THE COMMISSION'S RULES REGARDING DEDICATED SHORT-RANGE COMMUNICATIONS SERVICES IN THE 5.850-5.925 GHZ BAND (5.9 GHZ BAND), 17 FCC RCD. 23136 (2003).

[73] FED. COMMC'N COMM'N, *supra* note 72.

[74] *See* FED. COMMC'N COMM'N, ET DOCKET NO. 19-138, FIRST REPORT AND ORDER: USE OF THE 5.850-5.925 GHZ BAND (2020) (The vast majority of authorized devices in the band would be licensed by rule under Part 95.).

[75] FED. COMMC'N COMM'N, Use of the 5.850-5.925 GHz Band, 86 Fed. Reg. 23281 (May 3, 2021).

"By this action, we allocate 75 megahertz of spectrum at 5.850-5.925 GHz to the mobile service for use by Dedicated Short Range Communications ("DSRC") systems operating in the Intelligent Transportation System ("ITS") radio service. ITS services are expected to improve traveler safety, decrease traffic congestion, facilitate the reduction of air pollution, and help to conserve vital fossil fuels. DSRC systems are being designed that require a short range wireless link to transfer information between vehicles and roadside systems."[76]

Some opposed this allocation. In particular, "amateur radio interests" and Resound, a company using airwaves for hearing aids, preferred diverting the spectrum to support their applications.[77] They argued that the evidence did not merit "such a large allocation."[78] But the FCC responded: "we conclude that an allocation of 75 MHz is warranted" – and elaborated:

"First, we note that DSRC applications are a key element in meeting the nation's transportation needs into the next century and in improving the safety of our nation's highways. With this goal in mind, we agree with the DOT that it is important to provide sufficient spectrum to facilitate the development and growth of DSRC applications. For example, this allocation will ensure that adequate spectrum will be available for advanced DSRC applications that are anticipated in the future, such as Automated Highway systems, which could require several dedicated wideband channels to ensure service reliability. We also find that an allocation of 75 megahertz will provide the flexibility needed to share spectrum with incumbent operations."[79]

FIG. 1.FCC ALLOCATION FOR DSRC: 75 MHZ[80]

5.850 GHz							5.925 GHz
		CH175			CH181		
reserve	CH172	CH174	CH176	CH178	CH180	CH182	CH184
	service (vehicle-to vehicle)	service	service	control	service	service	service (high pow er)
5 MHz	10 MHz	10 MHz	10 MHz	10 MHz	10 MHz	10 MHz	10 MHz

At the time that the 5.9 GHz was being defined for DSRC applications, an adjacent band at 5.8 GHz – covering 5725-5825 MHz – was also a subject of interest. Seeking to promote the "Information Superhighway," the FCC had adopted rules in 1997 to allow access to 300 MHz of unlicensed frequencies dubbed the Unlicensed National

[76] FED. COMMC'N COMM'N, *supra* note 71.
[77] Julianne Pepitone, *The Uncertain Future of Ham Radio*, IEEE SPECTRUM (Jul. 10, 2020), https://spectrum.ieee.org/ham-radio [https://perma.cc/3DWB-JU7B].
[78] *Id.*
[79] *See* FED. COMMC'N COMM'N, *supra* note 71.
[80] FED. COMMC'N COMM'N, *supra* note 59, at 35.

Information Infrastructure (U-NII).[81] Three bands were specified,[82] and access was allowed for various low power devices.

The 1999 DSRC allocation at 5.9 GHz did not face a challenge from advocates of Wi-Fi, an application that was only just developing. On the other hand, hopes for DSRC in the 5.9 GHz band were high (as seen in the FCC language above) and remained so for some years. In 2004, for example, FCC Commissioner Jonathan Adelstein wrote in an agency DSRC Order, "I am optimistic that the rules we adopt today will further enable the wide-scale and interoperable deployment of these systems in the near future."[83] Yet, by 2010 progress was negligible. Regulators slowly revised. A 2012 report by the Department of Commerce's National Telecommunications & Information Administration identified the 5850-5925 GHz Band as meriting evaluation for potential reallocation.[84] The NTIA was to report back within 18 months.[85] In 2013, a new plan for possibly reconfiguring the Car Band was put forward by regulators. See Figure 2.

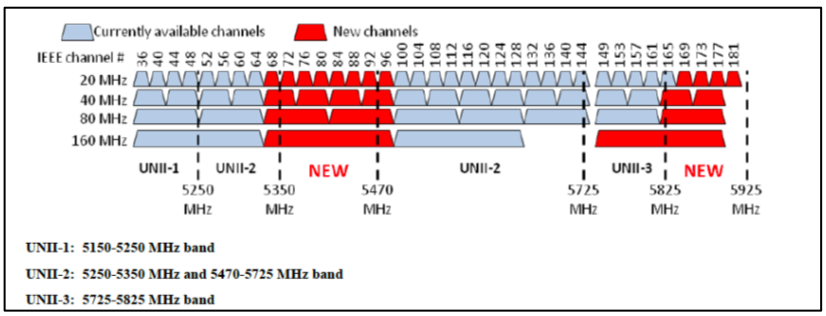

FIGURE 2.NEW AND EXISTING WI-FI CHANNELS IN THE 2013 5 GHZ BAND[86]

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[81] GENERAL ACCOUNTING OFFICE, FEDERAL COMMUNICATION COMMISSION: UNLICENSED NII DEVICES IN THE 5 GHZ FREQUENCY RANGE (1997).

[82] The bands were specified as U-NII-1 (5.15-5.25 GHz), 5.25-5.35 GHz (U-NII-2), and 5.725-5.825 GHz (U-NII-3). In 2003, another 255 MHz, 5.47-5.725 GHz augmented U-NII-2.

[83] Jonathan S. Adelstein, Extending Wireless Telecommunication Services to Tribal Lands (Aug. 6, 1999) (Fed. Commc'n Comm'n, separate statement by commissioner) (on file with author).

[84] U.S. DEPT. OF COMM., NAT'L TELECOMM. AND INFO. ADMIN., THIRD INTERIM PROGRESS REPORT ON THE TEN-YEAR PLAN AND TIMETABLE (2012).

[85] *Id.* (The 2012 "Tax Relief Act" mandated Commerce "to submit a report on the portion of the study with respect to the 5850-5925 MHz band not later than… August 22, 2013.").

[86] DEPT. OF COMM., EVALUATION OF THE 5350-5470 MHZ AND 5850-5925 MHZ BANDS PURSUANT TO SECTION 6406(B) OF THE MIDDLE CLASS TAX RELIEF AND JOB CREATION ACT OF 2012 (2013) (The "UNII" bands refer to the Unlicensed National Internet Infrastructure frequencies allocated during the 1990s. The

With this threat to uproot the ITS allocation, the DOT attempted a rescue. The agency sought to promote commercial auto telematics, and "took a lead role in the device development process."[87] To preserve the 75 MHz for automotive uses, in 2017 the agency proposed requiring all new vehicles sold in the U.S. to have DSRC built-in.[88] This would jumpstart demand for such devices, spurring industry output[89] despite technical problems and unsatisfactory safety reports.[90] In the fall of 2017, the FCC shelved the proposed DSRC mandate.[91] This appeared to open the door for reallocation of the Car Band.

But the battle was not over. Contentious exchanges between regulatory officials at the FCC, Department of Commerce, and Department of Transportation occurred. A coalition of tech companies and broadband ISPs pressured authorities to allow Part 15 unlicensed devices – notably, Wi-Fi chips and routers – to access the DSRC band, while auto makers actively defended the original allocation.[92] Until 2020, the status quo held. Lawyer (and reallocation advocate) Harold Feld described the stalemate in 2016:

"For the last 3 years, the auto industry and the Department of Transportation (DoT) have been at war with the open spectrum

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"new" bands (in red) were being proposed by the Department of Commerce to expand access for unlicensed devices associated with Wi-Fi services. "While the currently available channels support a number of combinations of these wider RF bandwidth channels, expanding the amount of spectrum authorized for U-NII device operation in the 5 GHz frequency range will increase the contiguous spectrum available to accommodate broadband applications. As shown in Figure 3-1, additional unlicensed use of 5.35-5.47 GHz and 5.85-5.925 GHz would allow nine 80 MHz channels and four 160 MHz channels (shown in red)." This latter reallocation would overlap with two thirds of the Car Band (5850-5925 MHz)).

87 DEPT. OF TRANSP., FHWA-JPO-16-363, SAFETY PILOT MODEL DEPLOYMENT: LESSONS LEARNED AND RECOMMENDATIONS FOR FUTURE CONNECTED VEHICLE ACTIVITIES (2015).

88 Federal Motor Vehicle Safety Standards; V2V Communications, 82 Fed. Reg. 3854 (proposed Jan. 12, 2017).

89 *Id*.

90 Brent Skorup, *The Department of Transportation's Proposed Vehicle-to-Vehicle Technology Mandate is Unprecedented and Hasty,* MERCATUS CENTER, at 10 (Apr. 2017), https://www.mercatus.org/research/public-interest-comments/department-transportations-proposed-vehicle-vehicle-technology [https://perma.cc/92X7-CY9E].

91 Marc Scribner, *VO2 Mandate Nixed: DOT Ends Second Most Costly U.S. Regulatory Proposal*, COMPETITIVE ENTERPRISE INSTITUTE (Nov. 1, 2017), https://cei.org/blog/v2v-mandate-nixed-dot-ends-second-most-costly-u-s-regulatory-proposal/ [https://perma.cc/GGW5-WAZ7].

92 Michael O'Reily & Jessica Rosenworcel, *Driving Wi-Fi Ahead: the Upper 5GHz Band*, FED. COMMC'N COMM'N (Feb. 23, 2015), https://www.fcc.gov/news-events/blog/2015/02/23/driving-wi-fi-ahead-upper-5-ghz-band [https://perma.cc/GFS5-MTFS].

community [over] 75 MHz of spectrum up at 5.9 GHz… So far, so normal. This is how spectrum politics works. Incumbents pay lip service to the idea of spectrum sharing, stress the awful terrible things that will happen if the Federal Communications Commission (FCC) allows the new entrant to operate and cause interference, and insists on an endless series of tests while dragging their feet on anything that would make testing possible. The new entrant, meanwhile, complains about how the other side is stalling, the interference claims are baseless, and hundreds of billions of dollars in economic benefits are lost as the delay continues.”[93]

II.2 FCC Reallocation in the 5.9 GHz Band in 2020

But the regulatory stalemate appeared to dissolve. In November 2020, the FCC ruled that reallocating 45 MHz of the 5.9 GHz band for unlicensed Part 15 (Wi-Fi) operations was "the most efficient use of spectrum" and in the public interest.[94] The analysis of costs and benefits was brief and only considered Wi-Fi and ITS uses as options.[95] The FCC expected that, when combined with the adjacent 5.8 GHz band designated for unlicensed Wi-Fi, the band would permit higher throughput for Part 15 devices,[96] and that the cost of upgrading existing ITS devices (to deploy only across the smaller, 30 MHz, allocation) would be minimal.[97] The regulatory cost-benefit analysis is explained in some detail below.

The FCC found that the set-aside for DSRC-based ITS had "not lived up to the original promise" and that spectrum set-aside had been underused for over 20 years.[98] In 1999, the agency and ITS proponents envisioned 32 distinct connected car services deploying in the band.[99] However, in the 2020 Order, the FCC noted that its original ITS plans had been overtaken by technologies using other spectrum bands, namely cellular, lidar, and radar applications.[100] The DSRC allocation – "a key element in meeting the nation's transportation needs into the

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[93] Harold Feld, *Auto Industry Crosses the Line on 5.9 GHz by Using Dead Pedestrians to Justify Spectrum Squatting*, PUBLIC KNOWLEDGE (May 6, 2016), https://publicknowledge.org/auto-industry-crosses-the-line-on-5-9-ghz-by-using-dead-pedestrians-to-justify-spectrum-squatting/ [https://perma.cc/US6U-SQ9W].
[94] FED. COMMC'N COMM'N, Use of the 5.850-5.925 GHz Band, 35 FCC Rcd. 13440, ¶¶ 20, 25 (2020).
[95] *Id.* ¶ 21.
[96] *Id.* ¶¶ 20-22.
[97] *Id.* ¶ 22.
[98] *Id.* ¶¶ 30-31.
[99] Intelligent Transportation Services, 64 Fed. Reg. 66405, ¶ 1.10 (Nov. 26, 1999).
[100] FED. COMMC'N COMM'N, *supra* note 94, ¶ 38.

next century and in improving the safety of our nation's highways,"[101] according to the FCC in 1999 – was deemed a failed experiment.

III. Spectrum Valuation for Liberal Exclusive Rights

In the years since the introduction of the DSRC band, cellular networks have migrated from second generation (2G) systems to 3G, 4G and 5G networks. The prime low and mid-band frequencies the FCC allots to flexible-use licenses (and then auctioned to mobile carriers) rose from about 180 MHz in 1999 to 1,133 MHz in 2020.[102] These augmentations are valuable to consumers and the firms that supply their wireless. In 2015, $41 billion was generated in the FCC auction of licenses granting control over 65 MHz of paired bandwidth (in the 1.7 GHz and 2.1 GHz bands); in 2017, a total of $19.8 billion was bid for licenses allocated 70 MHz (in the 600 MHz band); in 2020, $4.5 billion was paid for exclusive rights to licenses allocated 70 MHz (in the 3.5 GHz band);[103] in 2021, $94 billion was bid, in FCC payments and compensation to incumbent licensees, for rights to licenses allotted 280 MHz (in the 3.7 – 3.98 GHz band).[104]

Yet these magnitudes severely understate the total welfare gains associated with the allocations, in that they include producer surplus (approximating the bids made by profit-maximizing firms) but omit consumer surplus. The latter has been shown to typically be an order of the magnitude equaling the size of the former, or more.[105]

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[101] Intelligent Transportation Services, *supra* note 99, ¶ 1.9.

[102] *Sub-6 GHz Spectrum Screen and the Effects on the CBRS and C-band Auctions*, ALLNET INSIGHTS & ANALYTICS (Jul. 7, 2020), https://www.allnetinsights.com/blogs/spectrum-blog/sub-6-ghz-spectrum-screen-and-the-effects-on-the-cbrs-and-c-band-auctions [https://perma.cc/VXE4-AEM8].

[103] Winning Bidders Announced for Auction 97, 30 FCC Rcd. 630, ¶ I.1 (2015); Incentive Auction Task Force and Wireless Telecommunications Bureau Grant 600 MHz Licenses, 33 FCC Rcd. 869 (2018); Winning Bidders Announced for Auction 105, 35 FCC Rcd. 9287, ¶ I.1 (2020).

[104] Winning Bidders Announced for Auction 107, 36 FCC Rcd. 4318, ¶ I.1 (2021); *see also* Thomas W. Hazlett & Michael J. Marcus, *Why Couldn't the FCC and FAA Solve Their 5G Problem?*, CATO INSTITUTE (2022), https://www.cato.org/regulation/spring-2022/why-couldnt-fcc-faa-solve-their-5g-problem [https://perma.cc/QU3M-3J9U].

[105] *See* Gregory Rosston, *The Long and Winding Road: The FCC Paves the Way with Good Intentions*, 27 TELECOMMS. POL'Y 501, 513 (2003) (The FCC has noted, "some economists estimate that the consumer welfare gains from spectrum may be 10 times the private value to the spectrum holder."); Thomas W. Hazlett & Roberto E. Muñoz, *A Welfare Analysis of Spectrum Allocation Policies*, 40 RAND J. ECON. 424 (2009); Erik Brynjolfsson, Avinish Collis & Felix Eggers, *Using Massive Online Choice Experiments to Measure Changes in Well-Being*, 116 PROC. OF THE NAT'L ACAD. OF SCIS. 7250, 7252 (Apr. 9, 2019) (This finding is not a unique feature of mobile markets. For a range of digital services provided

Liberal rights supporting 5G applications on frequencies far higher than 5.9 GHz have also been sold at auction. The FCC has assigned licenses allocating millimeter wave frequencies at 24, 28, 37, 39 and 47 GHz in Auctions 101, 102, and 103 (held between 2018 and 2020).[106] Prices were much lower, per MHz, than for low-band (say, 600 MHz) or mid-band (say, 3.7 GHz) rights, while the allotments of millimeter wave bandwidth were far greater (in MHz).[107]

Smoothed values for existing mobile wireless licenses, as shown in Figure 3, display approximate current market spectrum valuations in price per MHz-pop (population in the licensed areas). The unweighted mean across the low and mid-band spectrum (excluding millimeter wave frequencies at 24 GHz and above) is $2.11 per MHz-pop (2021 dollars). Yet, price declines across higher frequencies due to propagation characteristics,[108] as shown graphically in Figure 4. A power function fitted to the relationship implies a valuation at 5.9 GHz = 16.7¢ per MHz-pop. At current population levels,[109] the private (supply side) value of the 75 MHz allocation is therefore an estimated $4.107 billion. Critically, this quantification applies prices revealed in bidding for exclusive, flexible-use spectrum rights. The bids generating this information are the product of firms investing their resources to procure the control of additional bandwidth, and indicate not a theoretical value, but rather a specific willingness to pay for access to incremental frequencies under particular rules (namely, liberal ownership rights). Under alternative regimes, options for deployment of the defined spectrum resources would presumably be altered, concomitantly changing both anticipated net benefits and bids. The policy choice to impose a distinct usage model forecloses this rights delegation, constituting an opportunity cost.

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by Internet platforms, "the surplus the median consumers receive from these goods is a 5 to 10 multiple of what they actually pay.").

106 FED. COMMC'NS COMM'N, *Auctions Summary*, https://www.fcc.gov/auctions-summary (last visited Oct. 1, 2022) [https://perma.cc/5RVB-A6XP].

107 *Id.*

108 COLEMAN BAZELON & GIULIA MCHENRY, MOBILE BROADBAND SPECTRUM: A VITAL RESOURCE FOR THE U.S. ECONOMY 15 (May 11, 2015) (prices for 700 – 2500 MHz allocations; Prices for 600 MHz and above 3600 MHz calculated from FCC data for Auctions 1002, 101, 102, 103, 105, and 107; Prices in 2021 dollars using CPI-U index levels for July of each year.).

109 *U.S. and World Population Clock,* UNITED STATES CENSUS (2021), https://www.census.gov/popclock/ (In January 2021, the U.S. population was about 332 million).

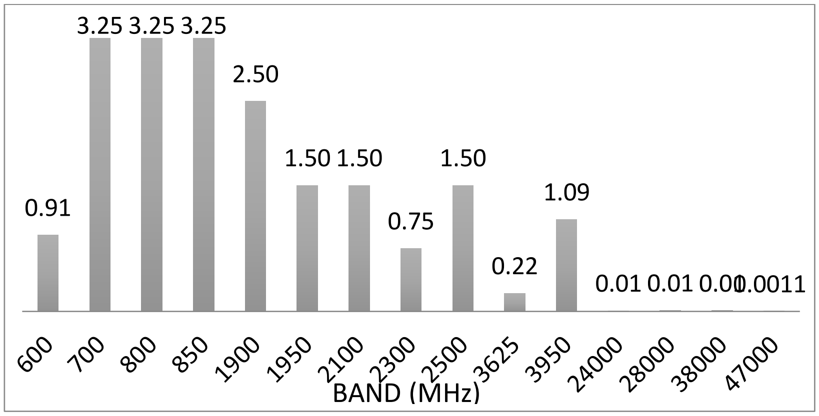

FIG. 3. ESTIMATED VALUES FOR FLEXIBLE-USE LICENSE BANDS (PRICE/MHZ-POP, $2021)[110]

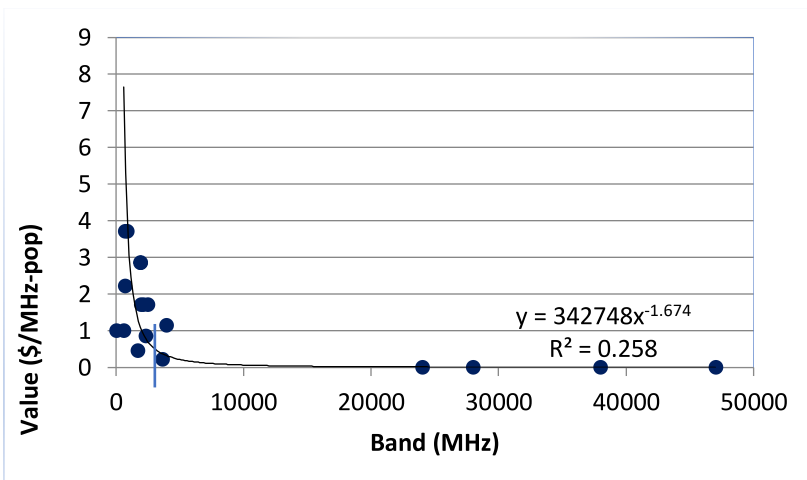

FIG. 3.1

[110] FED. COMMC'N COMM'N, *Auctions* (last visited Dec. 23, 2022), https://www.fcc.gov/auctions (Data for 600 (Auction 1002), 3625 (Auction 105), 3950 (Auction 107), 24,000 (Auction 102), 28,000 (Auction 101), 38,000 and 47,000 (Auction 103).); BAZELON & MCHENRY, *supra* note 108 (Data for 700 MHz, 800 MHz, 850 MHz, 1700 MHz, 1900 MHz, 1950 MHz, 2100 MHz, 2300 MHz, and 2500 MHz.).

IV.Rent Seeking in the Anticommons

Flexible-use spectrum rights permit reconfiguring spectrum use via contract.[111] The issuance of non-exclusive spectrum access rights, however, fragments control and renders negotiated contracts problematic.[112] Rule changes are imposed by public policy, which reacts to pressure groups seeking gains from influencing regulatory changes.

Years after the "Car Band" set-aside was established, commercial interests attempted to convert some or all of the allocation to Wi-Fi use. The 5.8 GHz unlicensed band, already hosting Wi-Fi services, would be expanded to encompass the adjacent 5.9 GHz ITS band.[113] Three basic arguments were offered.

1) Auto manufacturers have been given valuable airwave rights, for the purpose of developing Intelligent Transportation Systems, but have squandered the opportunity. "More than 15 years after the FCC allocated the band to the auto industry on a co-primary basis, the band mostly lies fallow…"[114]

2) The auto industry originally requested the 5.9 GHz allocation for "non-safety services such as navigation assistance, in-vehicle signage, driver advisories, toll collection and fleet management," but had switched priorities, coming to justify the set-aside mostly for collision-avoidance and other safety measures.[115] These applications "require at most" just 30 MHz. The automakers, however, plan to use the remaining 45 MHz in the band for services "already being delivered today over general-purpose wireless networks (e.g., cellular and Wi-Fi)."[116]

3) A proposal from wireless technology firm Qualcomm sought to move "time-sensitive" safety applications (involving car steering or braking, e.g.) to a specific 30 MHz block, and then allowing Wi-Fi radios to share the remaining 45 MHz.[117]

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[111] The enabling aspect of "flexible use" is key because, under traditional FCC licenses that specify services and technologies, such marketplace "change of use" has been banned.

[112] *See* HELLER, *supra* note 11, at Chapter 4 (In brief, transaction costs become prohibitive, locking in one use of resources when others have greater utility. A nice explanation can be found here.).

[113] Calabrese, *supra* note 68, at 9.

[114] *Id.* at 2.

[115] *Id.*

[116] *Id.* at 2-3.

[117] COLEMAN BAZELON & LUCREZIO FIGURELLI, THE ECONOMIC COSTS AND BENEFITS OF A FEDERAL MANDATE THAT ALL LIGHT VEHICLES EMPLOY 5.9 GHZ DSRC TECHNOLOGY 24 (May 2, 2016).

Car makers opposed the changes. The Alliance of Automobile Manufacturers, including twelve auto manufacturers such as Ford, BMW, General Motors, Volvo and Mercedes Benz, told the FCC that it welcomed the opportunity to share spectrum in the 5.9 GHz band – but that there must be "no harmful interference" to car-to-car or car-to-network communications.[118] Further, it argued that Qualcomm's plan "will likely result in interference."[119] In terms of costs and benefits, the spectrum choices "should be driven first and foremost by public safety," claiming that human lives are at risk if the 5.9 band plan should be altered.[120] Vehicle-to-vehicle (V2V) "technology, which is ready today, has the potential to prevent over 1,000 deaths a year. The future of this significant lifesaving technology lies in the hands of the FCC."[121] The coalition endorsed the idea of a government mandate requiring all new automobiles sold in the U.S. to include V2V radio systems. This regulation was advanced on the grounds of network effects.

Two observations are in order. First, the political rivalry evinced is just as observed in the administrative allocation system by Leo Herzel in 1951.[122] Herzel, a University of Chicago law student, had been impressed by Abba Lerner's 1944 book on market socialism and sought applications to improve social efficiency.[123] When pondering the FCC's rules for color television, which involved deciding upon a governmental technology mandate, he noted that the "arguments made me think immediately of socialist commissars debating the fine points of competing technologies."[124] Identifying the key issue to be "how the FCC could choose among competing technologies without resorting to mere regulatory rhetoric,"[125] Herzel suggested delegating decisions to competitive actors. The mechanism to achieve this would be for the FCC to define spectrum ownership rights, and then assign them by

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[118] THE ALLIANCE OF AUTOMOBILE MANUFACTURERS, IN THE MATTER OF: THE BENEFITS, CHALLENGES, AND POTENTIAL ROLES FOR THE GOVERNMENT IN FOSTERING THE ADVANCEMENT OF THE INTERNET OF THINGS 8 (Jun. 3, 2016).
[119] *Id.*
[120] Press Release, Global Automakers & ITS America, *Automakers, ITS Community Call on FCC to Protect the Safety Spectrum* (Jul. 8, 2016), https://docs.house.gov/meetings/IF/IF16/20160712/105179/HHRG-114-IF16-20160712-SD006.pdf [https://perma.cc/DMS2-DGQP].
[121] *Id.*
[122] Leo Herzel, *"Public Interest" and the Market in Color Television Regulation*, 18 U. CHI. L. REV. 802 (1951); Leo Herzel, *Rejoinder*, 20 U. CHI. L. REV. 106 (1952); Dallas W. Smythe, *Facing Facts about the Broadcast Business*, 20 U. CHI. L. REV. 96 (1952); *see also* R.H. Coase, *The Federal Communications Commission*, 2 J. L. & ECON. 1 (1959).
[123] *See generally* ABBA LERNER, THE ECONOMICS OF CONTROL (1944).
[124] Leo Herzel, *My Color Television Article*, 41 J. L. & ECON. 523, 525 (Oct. 1998).
[125] *Id.*

auction, allowing profit-seeking firms to discover and deploy the most efficient wireless solutions.

Second, rent seeking proceeds even where exclusive rights are not granted. Advocates for expanding the 5.8 GHz Wi-Fi band have argued that the "auto industry wants to retain near-exclusive use of the full 75 megahertz, without an auction and at no charge, but most of it would be used for commercial applications unrelated…."[126] This position was surely plausible, and proved persuasive, even as it was reciprocal: corporate interests pressed for expanded Wi-Fi access to airwaves "without an auction and at no charge" to benefit "commercial applications" – including those that were provided using other bandwidth and which may have been unrelated to extant claims – the very hope of innovative market disruption.[127] In any event, rents may be generated not only by the capture of exclusive rights, but in the tilting of "spectrum commons" to favor a given economic activity.

The question arises, as it did in 1951 for Leo Herzel: why not allow interests with differing views on the value of 5.9 GHz spectrum be put to the test? If the frequency rights were defined liberally and offered for sale, which consortium – the Wi-Fi Alliance or the Auto Alliance – would bid the most? More finely, if spectrum rights were defined and awarded such that responsible parties were able to engage in market transactions, how much of the band might shift from its 1999 band plan, and what would the precise repurposing look like?

Advocates of reform argued for a particular split, leaving 30 MHz for safety-related DSRC while permitting 45 MHz to be used by low-power Wi-Fi radios (in addition to DSRC applications).[128] The FCC gaveled this reform into policy in November 2020. But was this the optimal split? And, if so, will it be so tomorrow?

V. Rent Seeking Dissipation By Delay

As formulated in the classic treatment by Gordon Tullock, parties competing to obtain wealth transfers will tend to dissipate the discounted present value of the assets sought.[129] With firms lobbying to influence rules in the 5.9 GHz band, the sum of rent seeking and defending costs could, under this presumption, be predicted at about $4 billion. This formulation has drawbacks, however. First, while the dissipation estimate extrapolates from prices revealed in auctions, the

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[126] Calabrese, *supra* note 68, at 2.
[127] *Id.* at 2-3.
[128] *See* COMCAST CORP, IN THE MATTER OF: USE OF THE 5.850-5.925 GHZ BAND, ET DOCKET No. 19-138, (Mar. 9, 2020).
[129] Gordon Tullock, *The Welfare Cost of Monopolies, Tariffs and Theft*, 5 ECON. INQUIRY 224, 225 (June 1967).

non-exclusive use rights associated with either DSRC or Wi-Fi are not directly analogous. Second, Tullock's assumption of full dissipation does not persuasively describe every rent seeking episode.[130] Hence, it is observed that some contests result in much less than full dissipation[131]–[132]or more than full dissipation.[133]

The proportional magnitude of wasteful rent seeking may be to focus on resource dissipation attributed to delaying productive use. The regulatory timeline for reallocating the 5.9 GHz band offers plausible end points. The lag observed therein is not extraordinary. In 2010, the Federal Communications Commission, in its *National Broadband Plan*, identified substantial delays in spectrum allocation as the leading impediment to U.S. broadband development.[134] In an analysis of historic efforts to allocate or reallocate bandwidth, it concluded that between six and thirteen years was the typical administrative holdup. See Table 1.

TABLE 1.FCC SUMMARY OF DELAYS IN SPECTRUM ALLOCATION (TABLE 5-C IN FCC 2010)

Band	*First Step*	*Available for Use*	*Approximate Time Lag*
Cellular (1G)	1970	1981	11 years
PCS (2G)	1989	1995	6 years
Educational Broadband Service (EBS)/Broadband Radio Service (BRS) (2.5 GHz)	1996	2006	10 years
700 MHz	1996	2009	13 years
AWS-1	2000	2006	6 years

The endpoints on any particular rent seeking episode are subject to debate. The FCC's historic markers in the table above, for instance, are

130 Arye L. Hillman & Eliakim Katz, *Risk-Averse Rent Seekers and the Social Cost of Monopoly Power*, 94 ECON. J. 104 (Mar. 1984).

132 William R. Dougan & James M. Snyder, *Are Rents Fully Dissipated?* 77 PUB. CHOICE 793, 810 (1993).

133 Thomas W. Hazlett & Robert J. Michaels, *The Cost of Rent Seeking: Evidence from the Cellular Telephone License Lotteries*, 39 S. ECON. J. 425, 433 (Jan. 1993).

134 FED. COMMC'N COMM'N, CONNECTING AMERICA: THE NATIONAL BROADBAND PLAN, 77-78 (2010).

probably quite conservative. The delay in the introduction of cellular telephone, 1G analog technology, was characterized to be eleven years. Yet the FCC announced, in *1945*, that cellular technology was being developed and that licenses could soon be made available. They were eventually distributed in 1984-89.[135]

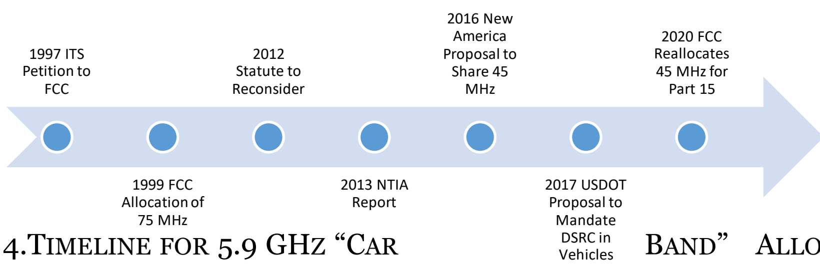

FIGURE 4. TIMELINE FOR 5.9 GHZ "CAR BAND" ALLOCATION BY FCC

The 5.9 GHz dispute dates to before 2012. In that year, a congressional statute directed the Department of Commerce to formally study the possibility that frequencies in the band be made available for sharing with technologies such as Wi-Fi. An estimation of proportional dissipation of social gains, *DR*, can be inferred from present value calculations.[136] For an asset yielding an annual (fixed) return, the proportional cost of a one-year delay is represented as:

$$DR = \{[1 - (1 + r)^{-N}]/r\}/(1/r) \qquad (1)$$

where r = social discount rate and N = number of years of delay. Intuitively, the ratio is the financial metric, present value interest factor for an annuity (PVIFA) of N years,[137] divided by the corresponding perpetuity value factor.[138] The calculated statistic measures the fraction of the present value of an infinite flow of benefits lost due to a finite delay at the start of the flow.

The profile of dissipation is displayed, across three different discount rates, in Figure 5. At six years, given a real discount rate equal to five percent (an assumption widely used in government cost-benefit

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135 HAZLETT, *supra* note 17, at 187.
136 The calculation is performed under the assumption that an investment produces a flow of constant annual benefits, is delayed for some years, meaning that the proportion of Present Value represented by those lost years are lost forever. This conforms to reality in the sense that the lost efficiency gains are not recouped later in time.
137 *See* Julia Kagan, *Present Value Interest Factor of an Annuity (PVIFA)*, INVESTOPEDIA (last updated Mar. 21, 2022), https://www.investopedia.com/terms/p/pvifa.asp [https://perma.cc/L9V3-FEL3].
138 *Id.*

calculations),[139] some 25.4% of value is lost. At ten years, 38.6%; at fifteen, 51.9%. Using the approach of the FCC National Broadband Plan, which identifies end points of a proceeding according to official documents (ignoring lobbying efforts preceding official action as well as legal skirmishing following issuance of an FCC Order), the 5.9 GHz reallocation from ITS to Wi-Fi consumed eight years, 2012 – 2020. This dissipated about one-third of the value of the new allocation, assuming a real social discount rate equal to five percent. With a reallocation process for the 5.9 GHz band lasting at least eight years, about one-third of band value has been dissipated, on the FCC's own terms. This assumes that regulators succeeded in defining optimal rules as of 2020.

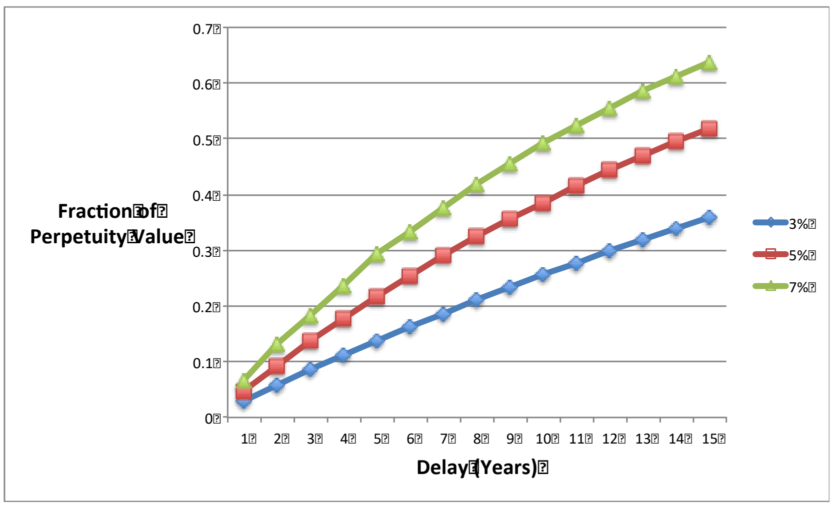

FIG. 5. RENT DISSIPATION SOLELY DUE TO DELAY

VI. Cost-Benefit Calculation by The FCC

In its November 2020 spectrum re-allocation the FCC performed a cost-benefit analysis. The Commission postulated that allowing use of 45 MHz the 5.9 GHz band for Wi-Fi would permit existing unlicensed allocations to be supplemented in a very particular way. This involved the use of additional channels to host data flows. These proportional increases would be used just as intensely as current available unlicensed frequencies. "Because future Wi-Fi traffic is expected to greatly increase and strain capacity today and in the

[139] Robert W. Hahn, *The Economic Analysis of Regulation: A Response to the Critics*, 71 U. CHI. L. REV. 1021, 1026 (2004).

future," writes the FCC Order, "we assume that the additional 5.9 GHz spectrum will be fully used by consumers."[140]

The Order initially justifies its move by citing a comment that "existing unlicensed bands 'could be rendered unusable by increasing demand.... by one estimate we're going to need to find 1600 [MHz] of additional unlicensed spectrum to meet busy-hour demand by 2025."[141] This assertion that unlicensed spectrum will become "unusable" because it's too congested is a reprise of the Yogi Berra line that "no one goes to that restaurant anymore because it's too crowded," and it mistakenly purports to value network inputs without considering margins or alternatives. Indeed, a concession that unlicensed bands tend to dissipate in value would as easily be interpreted as an argument that a different form of rationing access would more efficiently coordinate conflicts.

VI.1. The FCC's Basic Arithmetic

The FCC's cost-benefit analysis begins with a determination that the one question of interest is: What is the net social benefit associated with shifting 45 MHz of the 75 MHz "Car Band" to spectrum sharing for Wi-Fi access? The only input substitution considered is that more spectrum is allocated to Wi-Fi. The only cost considered is that ITS services will incur some expense in restricting wireless transmissions to a band that is reduced by 45 MHz.[142] The key elements in the FCC analysis are that:

(1) existing Wi-Fi traffic is a reported percentage of total residential broadband traffic;[143]

(2) the 45 MHz reallocation will expand channels used for Wi-Fi by 8.4%, assumed to produce an instant and commensurate increase in Wi-Fi data traffic, by 8.4%;[144]

(3) the percentage data increase is then converted to an annual volume (in GBs);[145]

(4) the new Wi-Fi data flows are assumed to have the same incremental value, per bit, as existing (inframarginal) Wi-Fi traffic;[146]

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[140] FED. COMMC'N COMM'N, *supra* note 75, n.365.
[141] *Id.*
[142] *Id.* ¶ 132.
[143] *Id.* ¶ 133.
[144] *Id.* ¶ 134.
[145] *Id.* ¶ 135.
[146] *Id.* ¶ 134.

(5) the asserted increase in Wi-Fi GBs per year converted into a monetary value by multiplying by the average price per GB paid by U.S. broadband ISP subscribers, calculated to be about $6 billion per year over 2023-25;[147]

(6) adjustment costs for ITS users limiting access to 30 MHz (instead of 75 MHz) will be *de minimis*;[148]

(7) the 45 MHz reallocation will generate net social gains of about $6 billion per year.[149]

The analysis does not, as purported, quantify the marginal increase in net benefits available to U.S. consumers from the studied spectrum reallocation. Rather, it conducts an exercise that focuses on how one particular conflict – the interference between ITS and Wi-Fi networks – could be engineered to favor more of one service at the expense of the other. The valuations deduced are mis-specified, but that itself is not a problem worth fixing within the FCC's chosen cost-benefit structure. Because the moved (disfavored) service generates virtually no value using airwaves set aside for their use by regulatory fiat more than twenty years ago, the reported cost of this specific action is unsurprisingly miniscule. But restricting the choice set to the two options narrowly hypothetically designed in the FCC proceeding makes the exercise an administrative justification rather than an exploration of comparative value. That is because it sidesteps the actual choice confronting society, which has countless other wireless opportunities that might be enhanced using inputs from the 5.9 GHz band. These rival productivities include opening 75 MHz (or any subset thereof) to non-ITS, non-Wi-Fi services. One obvious pathway foreclosed by FCC assumption is to define liberal use rights to the band, allowing parties to bid for bandwidth and then utilize airwaves for new or existing services.

Not only does the FCC not consider a policy option that, deployed scores of times by the Commission, would facilitate discovery of the highest valued uses of the 5.9 GHz frequencies – it refuses to recognize the possible gains from such market allocations in its analysis. In so doing, it truncates its own calculations. While enterprises seeking to maximize profits or, alternatively, to fulfill non-profit missions, tend to carefully evaluate the relevant margins for optimization, the FCC's purported cost-benefit analysis omits:

[147] *Id.* ¶ 135.
[148] *Id.* ¶ 141.
[149] *Id.* ¶ 125.

* The possibilities for input substitution. The cost-benefit exercise assumed simply that expanding (just) bandwidth would result in an identified output gain. This invokes the (very strong) assumption that varying one input is the efficient way to alter capacity. Suppose that a farmer knew that increasing land under cultivation by 40% would increase crop yields by 20%, holding all other inputs (seed, water, fertilization, pesticides, cultivation activity, harvesting, etc.) constant. That would not imply that the marginal land should be deployed, of course: it would depend on its rent (its opportunity cost), the cost of the alternative strategies for increasing output (e.g., spending more on fertilizer); and the demand for the additional output. None of the three factors is properly accounted for in the FCC cost-benefit study.

* The correct margin for evaluating changes. The FCC approach is to simply extend inframarginal traffic patterns to assumed gains. Tellingly, the Commission made no effort to determine how much of the 75 MHz "Car Band," under its assumptions, would optimally be reallocated. It simply evaluated a given proposal, put forth by advocates for Wi-Fi spectrum sharing (cited above), and concluded that the specific reallocation would generate a net social gain.

* A price for the incremental Wi-Fi service. This quantifies the demand for marginal output gains, and the FCC exercise borrows ISP broadband service fees as a proxy. But the ISP service is not Wi-Fi service, and the services are both supplied and sold distinctly.

* The opportunity costs of the 45 MHz reallocated (or the 75 MHz "Car Band" allocation in general).[150]

These lacunae render the FCC analysis meaningless for defining welfare tradeoffs. Yet they do reveal the grounds on which administrative choices are being made. The quantification serves as justification rather than discovery. It strongly suggests that improved institutional design – making choices transparent and aligning decision-maker incentives with social benefit creation – be developed to augment or replace the current regulatory approach.

VI.2. Singular Assessment of Combinatorial Problems

[150] Another omission in the FCC's methodology involves the explicit consideration of administrative costs, including the resource dissipation that occurs in competition among interest groups to alter rules over time. This issue has been discussed in this paper's section on rent seeking costs associated with delays caused by fixed allocational rules.

The capacity analysis is represented by the Commission to demonstrate marginal gain. But the increase in bandwidth is not the only way more bits can be transmitted. Moreover, there are multiple ways for networks to adjust to additional demands, including the adoption of more or better (more expensive) wireless routers, more bandwidth, pricing access, tightening power limitations, reconfiguring network architectures (perhaps relying more on cached services and local storage), queuing (slowing data transfers), and shifting to lower bandwidth-consuming technologies (texting over voice, e.g.). For instance, communications networks in general, and Wi-Fi systems in particular, are programmed to degrade rather than collapse during peak loads. If speed-enabling inputs were free, desired throughput levels would be maintained without cost. But, in fact, tradeoffs exist both because the economic inputs are diverted from alternatives, and because there are competing ways to add output.

The method presented by the FCC, despite a superficial attempt to anchor on market data (for prices and quantities), does not consider either the value of the marginal product of the regime assertedly evaluated, nor the cost of excluded opportunities. The approach ignores the basic economics of valuing radio spectrum rights. Ronald Coase, William Meckling and Jora Minasian explained these factors in a 1962 paper for the RAND Corporation:

"There are various combinations of resources – transmission power, antenna height and directivity, frequency of transmission, method of propagation, etc. – that can be utilized to achieve a given level of (received) power at a point distant from the point of transmission. The *range* of alternative combinations is determined by technology – the state of the arts – and is an engineering problem. The "proper" combination actually to use to achieve a given goal is, however, an *economic* problem and is not (properly) soluble solely in terms of engineering data.[151]

The use of a radio frequency by one person, if the frequency really is a scarce resource, will make this frequency less useful to others (perhaps even causing them to abandon its use altogether). This means that the gain which accrues as a result of the use of a radio frequency by one

[151] R.H. Coase et al., *Problems in Radio Frequency Allocation*, RAND CORPORATION DRU-1219-RC, 23 (Sept. 1995), https://www.rand.org/pubs/drafts/DRU1219.html [https://perma.cc/Z9D5-JLC8] (emphasis original) (This paper was written for Rand in 1962, but was suppressed due to political considerations. See the colorful description given in R.H. Coase, *Comment on Thomas W. Hazlett, Assigning Property Rights to Radio Spectrum Users: Why Did FCC License Auctions Take 67 Years?* 41 J. OF L. & ECON. 577 (Oct. 1998).).

person is always accompanied by a loss which results from the impairment of its usefulness to others. It is obvious that a person should be allowed to use a radio frequency only in those cases in which the gain exceeds the loss. Otherwise, there is a 'wasteful use'… The function of the FCC is to prevent such 'wasteful use.'"[152]

The FCC's analysis is conducted solely by postulating that more spectral inputs will create more data service. This omits the very considerations at issue in an allocation. First, output gains need be ranked, in terms of value, to discover the most productive input combinations. But the FCC selected only ITS and Wi-Fi, in one proportion (30/45), to examine. Second, both the output values and the input costs of comparative solutions must be considered in order to identify efficient outcomes. Perhaps the Wi-Fi traffic, which tends to be tethered to local area networks, adds lesser value per bit than 5G emissions, which may yield greater geographical coverage. Even for similar gains in output, the opportunity costs to produce those gains may differ. If Wi-Fi networks, for instance, can be reconfigured by adding base stations at relatively low cost, then the gain in output associated with a given spectrum allocation increase is relatively less valuable.

This simply restates that economic outcomes may be constructed with different "combinations of resources." The spectrum reallocation marginal product nets out the most economical *other* way to produce the anticipated gain. Yet, save for the expense incurred by ITS devices to adjust to a narrower band, opportunity costs were ignored. No consideration was given to deploying other networks. Such selectivity unduly narrows the economic effects considered in the valuation exercise, opening the door to errant "cost-benefit" projections produced in rent seeking campaigns.[153]

VI.3. Quantity Change

The FCC's 2020 5.9 GHz reallocation Order offered "Detailed Traffic Calculations." The exercise presented dollar estimates to forecast the impact of increasing unlicensed Wi-Fi allocations by 45 MHz, reducing the ITS band by the same allotment.[154] The clarity reveals how regulators quantified costs and benefits of the regime shift.

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[152] Coase et al., *supra* note 150, at 75.
[153] Hazlett & Honig, *supra* note 56, at 106-7 (In fact, broadcast TV interests have used this methodological format (ignoring input substitution, proper valuation margins, and opportunity costs) to produce studies showing that the highest values associated with the traditional TV Band allocation (dating to before 1952) are categorically associated with over-the-air broadcasting.).
[154] FED. COMMC'N COMM'N, *supra* note 75, at 101.

To predict what level of additional broadband service would be created by the policy change, the FCC compiled a list of the existing bands used for Wi-Fi traffic.[155] It then posited how many extra such bands – 20 MHz, 40 MHz, 80 MHz and 160 MHz – could be accessed by wireless users given an additional 45 MHz dedicated for the task. Using existing estimates for the proportions of data traffic already flowing over the differently sized bands, it then assumed that the bands created would raise data consumption by a proportionate quantity: an increase of one channel of given bandwidth in a category (bandwidth size) having ten Wi-Fi channels would then be predicted to increase GBs consumed by 10%.[156] Using a weighted average of the existing band flows, the FCC projected an overall "growth in Wi-Fi traffic" equal to 8.42%. See Table 2.

TABLE 2.FCC'S ASSUMED TRAFFIC INCREASES FROM 45 GHZ ADD TO WI-FI SPECTRUM

Channel Width	a. Ratio of Existing Traffic	b. # Existing Channels	c.# New Channels	Weighted Avg. [(a)*(c/b)]
20 MHz	.1	71	3	0.0042
40 MHz	.1	34	2	0.0059
80 MHz	.5	16	1	0.0313
160 MHz	.3	7	1	0.0429
Sum = Assumed Wi-Fi Traffic Increase as Proportion of Existing Wi-Fi Use				+0.0842

Source: FCC (2020, Appendix C, Figure C-1)

The assertion that a 45 MHz increase in allocated bandwidth for Wi-Fi would lead to an 8.42% gain in Wi-Fi usage is highly aggressive. Projecting that additional unlicensed bands will be instantly utilized as heavily as inframarginal frequencies is contrary to economic logic and empirical experience. Switching decentralized users (in WLANs) to new bands typically takes many years. This is seen in the migration of Wi-Fi from the 2.4 GHz band, where it launched on an 83.5 MHz ISM (Industrial, Scientific and Medical) license-exempt band in 1999,[157] to less crowded 5 GHz frequencies over a decade later.

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[155] *Id.*
[156] *Id.*
[157] Jeff Abramowitz, *How Wi-Fi Almost Didn't Happen*, WIRED (Sept. 12, 2019), https://www.wired.com/story/how-wi-fi-almost-didnt-happen/ [https://perma.cc/93BH-X2CK].

In fact, the allocation for unlicensed local area networks to access 5.8 GHz had already been made in 1997, opening another 100 MHz for Wi-Fi and an IEEE radio chip standard (802.11a), and was approved for accessing the new band by 1999.[158] Still, the 2.4 GHz band had a head start, being made available to spread spectrum devices in FCC Orders in 1985 and 1989,[159] and remained dominant. To simply distribute 5 GHz access capability into new devices being sold (abstracting from continuing usage among the embedded base) took many years. In 2015, 68% of Wi-Fi device sales included 802.11a technology; in 2019, near-saturation was (finally) achieved for new Wi-Fi devices sold, with 96% including 5 GHz capability.[160]

Moreover, the FCC calculates a gain of 8.42% in a finely tailored approach that observes Wi-Fi channels but ignores allocated bandwidth. The latter forms the basis for a more generic approach to spectrum policy, as relied upon by the agency itself. In its important, long-standing analysis of market concentration of mobile operators, a "spectrum screen" has been used for three decades to appraise (and limit) wireless carriers' bandwidth holdings focusing not on wireless channels but on generic spectrum holdings.[161] The screen, applied when carriers acquire licenses by merger, secondary trades, or FCC auction sales, applies extra scrutiny to holdings above approximately one-third the total bandwidth available for mobile networks. The logic is that regulators see bandwidth as a reasonable way in which to measure the opportunity for service to be supplied to the market by competitors (of the aggregating carrier).

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[158] Lee Badman, *5 GHz Is Finally Mainstream,* NETWORK COMPUTING (May 4, 2015), https://www.networkcomputing.com/wireless-infrastructure/5-ghz-finally-mainstream [https://perma.cc/UEZ9-X3HL] ("5 GHz has been available since 1999, with the ratification of the 802.11a standard." An additional 255 MHz was then allocated for unlicensed Wi-Fi in other 5 GHz frequencies in 2003.).

[159] Marcus, *supra* note 57, at 16; Hayes & Lemstra, *supra* note 57, §1.

[160] Badman, *supra* note 157.

[161] T-Mobile License LLC Cellco Partnership Applications for 3.7-3.98 GHz Band Licenses, 36 FCC Rcd. 11486, para. 2 (2021) ("Avoiding undue aggregation of spectrum in particular geographic markets has long been a bedrock principle of our wireless policy." The Order cites rules enforced by the FCC since 2004, but in fact the 1994-95 sale of PCS licenses (in FCC Auction 4) involved a similar restriction on spectrum (no carrier could own licenses allocated more than 45 MHz, preventing a cellular licensee – authorized to use 25 MHz – from acquiring a broadband PCS license – allocated 30 MHz – in the same geographic market. Some adjustments are made for the frequencies allocated; for instance, licenses to use millimeter wave frequencies (24 GHz and higher) confer less valuable rights, per MHz, than low-band and mid-band frequencies (up to about 6 GHz) and are treated differently under the FCC's spectrum screen.).

The established regulatory procedure would count the existing unlicensed allocations potentially available to Wi-Fi users and tabulate the proportional increase represented by the 45 MHz reallocation. In November 2020, such existing allocations equaled 2,139.5 MHz, making a 45 MHz supplement constitute a bandwidth gain of just 2.05%. This excludes the wide spaces allocated to unlicensed applications at millimeter wave frequencies, including only unlicensed frequencies below 7.1 GHz.[162] Hence, the unacknowledged shift in method produces more than a four-fold gain in the bandwidth increment which, in turn, directly drives the FCC's estimated output estimate.

The FCC's switch from *bandwidth increments* is further notable because the Commission, just months before the 5.9 GHz Order was issued, had reallocated its largest unlicensed band in low to mid-band spectrum. In the 6 GHz Order, announced April 23, 2020, the Commission added 1.2 GHz, and touted the addition as a *Wi-Fi bandwidth* increase: "Opening the 6 GHz band for unlicensed use will also increase the amount of spectrum available for Wi-Fi by nearly a factor of five and help improve rural connectivity."[163]

The Commission, however, claims its approach is "conservative," citing two industry-sponsored studies proffering more ambitious estimates.[164] That standard uncritically accepts valuation

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[162] This includes 170 MHz available for TV white space devices at 400-500 MHz; 26 MHz for ISM at 900 MHz; 10 MHz for U-PCS at 1.9 GHz; 83.5 MHz for ISM at 2.4 GHz; 70 MHz for CBRS at 3.5 GHz; 580 MHz for U-NII at 5 GHz; and 1,200 MHz at 6 GHz (allocated prior to the ITS Order in 2020 and recognized in the Order).

[163] News Release, Federal Communications Commission, *FCC Adopts New Rules for the 6 GHz Band Unleashing 1,200 Megahertz of Spectrum for Unlicensed Use* (Apr. 23, 2020), https://www.fcc.gov/document/fcc-opens-6-ghz-band-wi-fi-and-other-unlicensed-uses [https://perma.cc/RBN3-M2QR] (It perhaps bears noting that the Commission made no attempt to quantify the claimed >500% increase in value terms. Using the linear extrapolation embedded in the 5.9 GHz Order, and the $6 billion annual gains there associated with an estimated 8.42% channel increase, would predict annual "impact" of greater than $356 billion (= [(500/8.42) * $6 billion]). The implausibility of the projection speaks to the valuation methodology.).

[164] FED. COMMC'N COMM'N, *supra* note 75, at 101 ("We note that our use and distributional assumptions lead to highly conservative estimate [sic] of the reliance on 5.9 GHz channels relative to other studies." The FCC cites two other studies. The other study writes that the organization tasked with writing the report, Telecom Advisory Services LLC, "is an international consulting firm specialized in the development of business strategies and public policies for digital telecommunications companies, governments, and international organizations. Its clients include leading companies in the digital and telecommunications sectors, as well

claims of interested parties, contradicting the FCC's explicit rejection of the estimates of one of the cited papers as producing unverifiable and implausibly large estimates via an:

> "approach [that] suffers from conceptual issues—including assumptions on device data consumption rates–that lead to unusual outcomes. For instance, this approach indicates that the allocation of an additional 75 megahertz of unlicensed spectrum would lead U.S. consumers to purchase approximately an additional 146 to 160 million connected devices, which appears too high based on estimates reporting that there were between 400 million and 433 million U.S. connections in aggregate at the end of 2017."[165]

In fact, the projected gain by the RAND Study was for an addition 146 to 160 million connected device sales *per year*. The embedded base of 400-433 million took multiple years to create. The prediction was that *a 3.42% increase in bandwidth* for Wi-Fi access would increase sales of smartphones and other connected devices *by over 100% annually*.[166] The FCC Order rejected this forecast as implausible. It is, however, curious that the dismissed framework would then be positioned against the FCC approach to establish the latter as "conservative."

VI.4. Complementary Factors and Substitution

A more basic error embedded in the FCC's method is that it assumes, without qualification, that increasing one input (dedicated

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as international organizations such as the International Telecommunications Union, the World Bank, the
Inter-American Development Bank, the World Economic Forum, the UN
Economic Commission for Latin America and the Caribbean, the GSMA Association, the CTIA, the NCTA, Cable Europe, the Wi-Fi Alliance, and
the FTTH Council (of Europe).); Marjory S. Blumenthal et al., *The Potential Economic Value of Unlicensed Spectrum in the 5.9 GHz Frequency Band:
Insights for Future Spectrum Allocation Policy,* RAND, iii (2018) https://www.rand.org/pubs/research_reports/RR2720.html
[https://perma.cc/GY9H-FJ4Y] ("This research was funded by the Comcast Innovation Fund."); Raul Katz, *Assessing the Economic Value of Unlicensed
Use in the 5.9 GHz & 6 GHz Bands,* WIFI FORWARD, 2 (Apr. 2020) http://wififorward.org/wp-content/uploads/2020/04/5.9-6.0-FINAL-for-distribution.pdf [https://perma.cc/H6TT-3LBD] (This study is published by WifiForward and funded by a subset of those members. The author is solely responsible for the views expressed in this study. WiFiForward is supported
by Google, Microsoft, Comcast, and numerous other Internet software and
services companies.).

[165] Use of the 5.850-5.925 GHz Band, 34 FCC Rcd. 12603, n.108 (2019).

[166] The difference in this ratio from the FCC's 2.05% increment is due to the
fact that the RAND study assumed a 75 MHz reallocation from ITS to Wi-Fi, whereas the FCC studied a 45 MHz reallocation.

bandwidth) will increase total output by that exact proportion. Only one path to the increase, defined by asserted engineering relationships, is considered as a result of the change. None other of the "various combinations of resources" are considered. To identify this one arbitrarily configured change as an efficient improvement is incorrect.

By way of simple example, assume that the FCC's 8.42% Wi-Fi data traffic increase prediction (following from an 8.42% increase in traffic-weighted wireless channels) were correct. That is, the 45 MHz supplement would, in fact, result in such a data usage gain without adjusting any other factors. Suppose, further, that the extra output is valued at *$X*. The value of the marginal spectrum allocation is still undefined. To remedy that, we must specify two further conditions. First, that the same 8.42% output gain could be generated by exactly one distinct pathway: extra Wi-Fi equipment expenditures of *$0.75X*.[167] Second, that the opportunity cost of the 45 MHz is found to equal *$1.25X*. Accounting for alternative methods for producing the output gain, and including the foregone benefits from rival spectrum uses, lead the cost-benefit conclusion to shift. Whether that conclusion is correct depends on the actual values. But the FCC framework disregards those key factors altogether. These omissions will be revisited when we examine a policy alternative not considered: competitive bidding among the rivals seeking distinct 5.9 GHz access rules.

That unlicensed radio spectrum users are awarded non-exclusive resource use rights effectively eliminates the opportunity for secondary market reallocations. It leaves intact the reality that one input increase does not automatically force a commensurate output increase, and obscures market forces that tend to constrain resource utilization choices to "combinations" that achieve optimal results. When rice farmers are allocated water rights in the arid Sacramento Valley, and the rights cannot be resold, rice output increases from what would otherwise obtain – but the outcome is anti-social.[168] And because

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[167] *See*, e.g., A. Habib et al., *An Efficient Cross-tier Interference Mitigation Technique in LTE Femtocells Environment*, 178 INT'L J. OF COMPUT. APPLICATIONS 37 (Sept. 2019) (on the use of local hotspots supplied by 4G femtocells); Of course, various output-expanding options exist. Improved internal wiring; additional "hot spots" (relays, beacons, routers, etc.); upgrading Wi-Fi channel-switching technology. Of particular interest in the 5.9 GHz reallocation might be the competitive margin between Wi-Fi hotspots and femtocells or picocells.

[168] Somini Sengupta, *It's Some of America's Richest Farmland. But What Is It Without Water?*, N.Y. TIMES (Jun. 28, 2021), https://www.nytimes.com/2021/06/28/climate/california-drought-farming.html [https://perma.cc/KYR8-NUQL] (The ironic answer to the article's headline

rights are assigned by administrative allocation, without the practical possibility of reselling, parties are rigidly held to suboptimal resource use.

VI.5. A Price Proxy for Wi-Fi Bits

To translate its postulated output gains into economic values, the FCC multiplies quantities of data (GBs) by "the average ISP revenue generated by an [sic] GB of traffic."[169] This process is described in Appendix C of the Nov. 2020 FCC 5.9 GHz reallocation Order. That document describes sources and methods, as summarized in Table 3.

The "Benefit Calculations" begin with "Traffic Projections." Cisco projections are cited for total broadband service (business and residential) consumed in 2023-2025, and a 2017 baseline (when actual data were available). The proportion of total Internet data traffic that flows through Wi-Fi routers is also taken from Cisco. In 2023, e.g., the prediction is that 1,159 billion GBs of data will flow in the U.S., of which 660 billion GBs will be over Wi-Fi.[170] The projected increase in Wi-Fi traffic – 8.4% – is then applied to this magnitude to produce estimated Wi-Fi data increases per year. The figure is given as 56 billion GBs in 2023.

How much this is worth to the U.S. economy – what the FCC will call "impact," as measured in revenues –[171] is then tabulated. This

question is: *more valuable – often by an order of magnitude*. Rice, a water-intensive crop, came to be grown in arid regions, including the Sacramento Valley, due to "free water" dedicated to the task by federal water project allocations. Traditionally, the water rights have been frozen in place, barring highly valued water to shift away from rice production, which produces comparatively little value at the margin. Reforms in recent decades now allow some market transactions. One Sacramento Valley rice farmer deals with drought by leaving virtually all of his rice fields fallow. A "crisis presents rice farmers in the Sacramento Valley... with a tricky choice: Should they plant rice with what water they have, or save themselves the toil and stress and sell their water instead? Mr. Fiack, a second-generation rice farmer, chose to sell almost all of it. At $575 per acre-foot (a volume of water one acre in size, one foot deep) the revenue compares favorably to what he would have made growing rice.").

[169] FED. COMMC'N COMM'N, *supra* note 75, ¶ 135 (footnote omitted).

[170] This double-counts, in that broadband ISPs are transporting bits to and from users' premises, with local hand- offs to and from devices via local area network wired or wireless routers (with the latter hopping over unlicensed frequencies). Individual LAN traffic volumes across categories (Wi-Fi, CAT-5, or Ethernet) may shift without impacting overall data consumption by ISP customers.

[171] This again ignores opportunity costs, including what could be done with an alternative use of the 45 MHz reallocated to unlicensed access in the ITS band, as well as any costly adjustments used to facilitate the use of the 5.9 GHz bandwidth. As noted in footnote 165, refurbishing routers and devices is not

calculation is made using three different estimated prices to value the data flows, of which the FCC advances the "IDBR Based Analysis" as best. This uses the FCC's 2018 International Data Broadband Report which states that, in 2017, U.S. broadband ISPs – Verizon, Comcast, Charter, AT&T, etc. – charged subscribers a reported average of $0.34 per GB.[172] The FCC employs this statistic as a price proxy for Wi-Fi service, multiplying by the asserted increase in Wi-Fi data traffic. The linear extrapolation – valuing a percentage increase in GB consumption at prices paid for inframarginal bits – is dubious, as both economic theory and econometric studies suggest that diminishing marginal value per GB.[173] Consumers demonstrate a willingness to pay for 1,000 GB per month that is substantially less than twice the WTP for 500 GB.

Even more fundamentally, broadband ISP service does not proxy the value of Wi-Fi service. Wide area network (WAN) and wireless local area network (WLAN) services are complements, but also distinct products, traded in their respective markets with valuations reflecting marginal costs and benefits specific to either.

TABLE 3.FCC CALCULATIONS VALUING INCREASES IN WI-FI SERVICE (PER EXTRA 45 MHZ OF UNLICENSED SPECTRUM IN 5.9 GHZ BAND)

		2017	2023	2024	2025	FCC Source
	Traffic Projections					
(a)	Total Internet Traffic (GB billion)	337	1,159	1,296	1,433	Cisco

costless, and doing do quickly, with a premium charged "early adopters", is more expensive. This fact is in tension with the assumption of instantaneous full employment (by FCC standards) of the incremental bandwidth.

[172] FED. COMMC'N COMM'N, *supra* note 75, at 105.

[173] Yu Hsin Liua et al., *Distinguishing bandwidth and latency in households' willingness-to-pay for broadband internet speed,* 45 INFO. ECON. AND POL'Y 1 (Dec. 2018) ("We find that households' valuation of bandwidth is highly concave, with relatively little added value beyond 100 Mbps… although consumers place a significant premium on unlimited service.").

(b)	Wi-Fi Traffic (GB billions)		660	742	824	Cisco
(c)	Increase in Wi-Fi Traffic (GB bil.)		56	62	69	8.4% * (b)
	Revenue Analysis (IDBR)					
(i)	Unit Internet Price Level (1997=100)	76.5	77.5	77.6	77.6	CPI
(j)	Residential Traffic (GB bil.)	145	500	559	618	.431 * (a)
(k)	No. Internet Households (mil.)	100	120	120	130	FCC data
(l)	Monthly data usage per HH (GB)	123	346	375	403	(j/k)/12
(m)	Internet price level/GB (1997=1.0)	.62	.22	.21	.19	(i)/(l)
(n)	Internet price level/GB (2017 = 1.0)		.36	.33	.31	(m)/2017 value
(o)	Avg. Fixed Broadband Price ($GB)		.12	.11	.10	(n) * $0.34 [2017 price/GB, per IBDR]
(p)	Impact [revenues] (bil.)		$6.8	$7.0	$7.3	(o) * (c)
(f)	Impact present value @ 7% discount from 2020 (bil.)		$5.9	$5.7	$5.6	(p)/(1.07)^(year-2021)

Source: FCC (2020), Appendix C, Figure C-1.

Important spatial characteristics differ sharply between WAN and WLAN services. Broadband ISPs send and deliver subscribers' data packets across "the last mile," and more. A standard Wi-Fi network has a radius less than 300 feet.[174] To assert that the transmission of one bit locally is of equal value to the transmission of the same bit widely, the assumption made implicitly in the FCC analysis and one made explicitly in other papers,[175] is a rule that imposes an arbitrary metric that ignores not only distance but demand.[176] While the average U.S. broadband household purchases service for about $956 per year (using the 2020 subscriber revenue data relied on the FCC)[177], a household can install a Wi-Fi service to distribute such traffic locally (within the residential unit) for about $36 a year, assuming a five year life for such units.[178] In fact, such routers are typically included by broadband ISPs with installed modems, a bundling that underscores the complementarity between broadband ISP service and Wi-Fi. Indeed, the FCC asserts:

"Every approach [used by the FCC] assumes that Wi-Fi revenue from transactions between ISPs and their customers is proportional to increases in Wi-Fi traffic. Additionally, each approach incorporates fixed broadband prices and revenues because Wi-Fi traffic is typically paid for indirectly via a fixed broadband subscription."[179]

But complementarity does not imply that bundled products, when separated, are identical in terms of value. An automobile sold by Tesla includes batteries; the price of a Tesla is not a proxy for batteries.

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[174] Bradley Mitchell, *What Is the Range of a Typical Wi-Fi Network? Does your Wi-Fi give you the coverage you need?*, LIFEWIRE (Nov. 6, 2020), https://www.lifewire.com/range-of-typical-wifi-network-816564 [https://perma.cc/ZB8W-RY3P] (Wi-Fi routers can also be linked in mesh networks, extending coverage, but costs are yet sufficiently high as to preclude mass market retail services substituting for fixed or mobile networks.);

Assaf Eilat et al., *The Case for Unlicensed Spectrum*, SSRN, 14 (Oct. 23, 2011), https://web.stanford.edu/~jdlevin/Papers/UnlicensedSpectrum.pdf [https://perma.cc/DEX4-V6KM]; Yochai Benkler, *Open Wireless vs. Licensed Spectrum: Evidence from Market Adoption*, 26 HARV. JL. OF L. & TECH. 69, 99 (2012).

[176] Hazlett & Honig, *supra* note 56, at 82-85 (development of this argument).

[177] FED. COMMC'N COMM'N, *supra* note 75, at 105 (The analysis lists average monthly broadband ISP service in 2020 as costing $79.67.).

[178] Komando Staff, *A powerful router if you have lots of devices: ASUS RT-AX3000,* KOMANDO.COM (Apr. 1, 2022) https://www.komando.com/news/a-powerful-router-if-you-have-lots-of-devices-asus-rt-ax3000/808627/ [https://perma.cc/ZKX5-T273] (Based on $165 (paid over five years and with a discount rate of five percent) for a state of the art, ASUS RT-AX3000 two-band Wi-Fi router, as recommended to well-serve an average 3,000 square foot home.).

[179] FED. COMMC'N COMM'N, *supra* note 75, n.370.

U.S. regulatory authorities define product markets when investigating mergers in the broadband space, and Wi-Fi services are explicitly excluded as substitutes for wide area network services. In the T-Mobile-Sprint combination, consummated in 2020, antitrust authorities defined the service as being "RMWTS" - retail mobile wireless telecommunications services. Networks included: Verizon, AT&T, T-Mobile, Sprint (pre-merger), DISH (post-merger).[180] No Wi-Fi service retailers were considered relevant. In a 2016 merger of two major cable TV providers, Charter and Time Warner Cable, the FCC defined the product market as "broadband Internet access service" (BIAS). This was limited to fixed services, and all wireless services were excluded.[181]

VI.6. Benefits ~$6 billion per year, Costs <$500 million per year – per the FCC.

The FCC arrives at the conclusion that residential Wi-Fi usage in 2023 will be sold (to broadband ISP customers) at 12¢ per GB (Internet access costs, per GB, falling precipitously, 2017-2023).[182] This implies that the value of increasing Wi-Fi traffic (from all markets, residential and business, as listed on lines (a) through (c)), by 8.4% produces an "Impact" equal to about $6.8 billion ($0.12 * 56 billion), $7.0 billion in 2024 and $7.3 billion in 2025 (line (p)). The FCC discounts to 2021 present values, which average slightly below $6 billion per year, 2023-25.

The FCC's consideration of costs focuses solely on "repurposing ITS spectrum."[183]

Various commentators claim that the costs of reducing the spectrum dedicated for IT substantially outweigh the benefits of dedicating 45

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[180] *See State of N.Y., et al., v. Deutsche Telekom AG, et al.,* 439 F. Supp. 3d 179, 193-94 (S.D.N.Y., Feb. 11, 2020) (Hence, when T-Mobile acquired Sprint, combining two of the top four wireless broadband suppliers in the U.S., the concentration questions addressed by regulators (and a federal court which heard a legal challenge to the merger brought by several states) was whether the post-merger T-Mobile would be a stronger rival platform in competing with Verizon and AT&T, and, secondly, would a new fledgling mobile operator, DISH (which purchased Boost Mobile, divested by Sprint, along with additional wireless licenses spun off by the merging parties), be a viable competitor.)..

[181] Application of Charter Communications, Inc., Time Warner Cable Inc., and Advance/Newhouse Partnership for Consent to Assign or Transfer Control of Licenses and Authorizations, 31 FCC Rcd. 6327, paras. 50-53 (2016).

[182] The FCC appears to err in Fig. C-2, particularly on lines (m) and (n) shown here in Table 3. The Internet Price Level is displayed in both lines, and calculated and sourced differently, and described in oddly different ways. They are made uniform here.

[183] FED. COMMC'N COMM'N, *supra* note 75, ¶ 129.

megahertz for unlicensed operations.[184] However, rather than quantifying costs specific to the reduction in IT, most commenters point to the economic impact caused by automobile collisions in aggregate throughout the United States each year....

Commenters also argue that repurposing ITS spectrum would lead to costs associated with traffic congestion, and auto emissions, and in most instances, do not connect these costs to ITS.[185]

More generally, commenters express concern that repurposing spectrum in the 5.9 GHz band would delay the spread of ITS applications in the United States....
Finally, ITS advocates argue that existing ITS licensees would face a transition cost above $500 million with specific reference to U.S. DOT estimates of infrastructure and equipment replacement costs.[186]

The FCC's point about the use of inframarginal values as inapt for the characterization of marginal values is a solid one. It is ironic, of course, that the Commission fails to appreciate that it has done the same thing (see discussion above and below). In any event, the FCC – under its analysis of the "Costs of Repurposing the Band to Limit ITS Use to the Upper 30 Megahertz of the 5.9 GHz Band" – makes short work of the claims regarding the expense of truncating ITS access: "[W]e do not believe that this proceeding will lead to cognizable costs due to automobile collisions that may be linked to our actions…"[187] It then relies on its marginal value estimation to more than offset any adjustment cost:

"Finally, we believe that the U.S. DOT's estimate of transitioning licensees is at the high end of total ITS transition costs, and is, in any event, well below our estimated benefit of repurposing the 5.9 GHz for unlicensed use."[188]

It is true that a one-time charge of a half-billion dollars is easily less that FCC-estimated benefits of $6 billion annually. But the FCC has not exhausted all of the possibilities; indeed, it has scarcely scratched the surface. The cost of generating Wi-Fi gains through means other than the 45 MHz reallocation is not considered, nor are the social gains of allocating the 45 MHz in question to exclusive, flexible-use rights.

[184] *Id.* ¶ 128.
[185] *Id.* ¶ 129.
[186] *Id.* ¶ ¶ 130-31 (footnotes omitted).
[187] *Id.* ¶ 140.
[188] *Id.* ¶ 143.

The Commission is alert to the necessity of calculating marginal valuations when critiquing pleas from other parties offering valuation assessments on inapt margins. To wit, addressing pro-ITS commenters opposing 5.9 GHz reallocation, the FCC Order writes:

"We have already noted that 30 megahertz of spectrum is sufficient to support many ITS applications and existing studies do not show that more spectrum would give rise to additional benefits."[189]

The FCC defends its argument that the ITS allocation is of low value, critiquing the Department of Transportation (DOT, which houses the NHTSA) for its valuation exercise applied to ITS by separating *spectrum allocations* from *wireless outputs*.[190] While V2X technology has begun to take off by use of cellular networks allocated liberal licenses (C-V2X), the FCC writes that "we note that C-V2X has had no spectrum dedicated to its deployment, but this has not prevented rapid innovation in this technology..."[191] Whatever benefits lurk in the emerging vehicle driving technologies do not prompt the FCC to cite engineering studies here, but to formulate a marginal analysis: "NHTSA's own prior analysis suggests that V2V safety applications that could eliminate a large proportion of crashes may require much less spectrum."[192] Other inputs do indeed substitute for frequency access, as the FCC here notes.

The insight cuts deeply – both against the ITS arguments *and against the FCC's estimation* which assumes that only by allocating a given 45 MHz band to Wi-Fi will certain benefits be obtained, and effectively for zero cost. It then credits the gross value of these purported gains to the FCC policy, failing to properly consider, and net out, the various substitution options and the opportunity cost of 5.9 GHz spectrum – other than (anemic) Car Band ITS applications. The FCC notes that "benefits and costs [must be] causally related to the Commission action being undertaken,"[193] but fails to follow that logic all the way through.

An alternative FCC policy action could include a 5.9 GHz rights reallocation to Commercial Mobile Radio Service (CMRS) licenses. Indeed, there are countless alternatives, but it is appropriate to think specifically of CMRS because (a) there are strong reasons, grounded in FCC regulatory practice and economic analysis, suggesting that CMRS is the highest valued of the alternative options (and it is the therefore the choice that is being foreclosed), and (b) the CMRS approach

[189] *Id.* ¶ 141 (footnote omitted).
[190] *Id.* ¶ 143.
[191] *Id.* ¶ 142.
[192] *Id.* ¶ 140 (footnote omitted).
[193] *Id.* ¶ 138 (footnote omitted).

conveys flexible-use rights ownership that accommodate a diverse set of technologies and business models. While the FCC claims that "we can credit economic losses only if they would be expected to result from repurposing the 5.9 GHz band", it appears to misunderstand its own cost-benefit framework. The economic losses that ensue from *FCC-imposed barriers to repurposing the 5.9 GHz band* are theoretically identical to (and, in this instance, of evidently far greater empirical value) than the relatively paltry costs considered in the Commission's net benefits analysis – those incurred to make existing ITS devices compliant with a smaller ITS band.

No consideration was given to any alternative beyond the failing ITS services, and the FCC asserted justification for its reallocation by rejecting this one (less valuable) option.[194] The Commission concluded its decision with this calculus:

"[S]uppose that, conservatively, the increase in traffic were only 1% [instead of 8.42%]. Using our lowest estimates of the value of this traffic still leads to a present value GDP contribution of $2 billion over 2023-2025 [about $700 million per year], which is still higher than expected one-time transition costs."[195][196]

This rendition of a sensitivity analysis is a straw man exercise that again excludes any opportunity cost save 5.9 GHz ITS. Wireless license prices suggest that bidders would pay about $4 billion for the band, yielding flexible-use exclusive rights to 75 MHz of 5.9 GHz bandwidth –and therefore about $2.4 billion for the 45 MHz reallocated in 2020 (see calculations in Section III). That is a lump sum bid reflecting the present value of property rights to the band. But the producers' surplus in such bids has been found to reflect consumer surplus magnitudes far larger; indeed, annual consumer surplus gains have been shown to approximate present values for producer surplus (estimated by winning license bids at auction).[197] Assuming this empirical finding to

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[194] Gretchen Stoeltje & Greg Winfree, *FCC Radio Spectrum Reallocation Could Impair Vehicle Safety*, TEX. A&M TRANSP. INST. (Nov. 2, 2020), https://tti.tamu.edu/news/fcc-radio-spectrum-reallocation-could-impair-vehicle-safety/ [https://perma.cc/CYK2-SXTU]; *see also* Tianxin Li & Kara M. Kockelman, *Valuing the Safety Benefits of Connected and Automated Vehicle Technologies*, THE UNIV. OF TEX. AT AUSTIN CIV. ARCHITECTURAL AND ENV'T ENG'G (2018), https://www.caee.utexas.edu/prof/kockelman/public_html/TRB16CAVSafety.pdf [https://perma.cc/J4M9-WUDN].

[195] FED. COMMC'N COMM'N, *supra* note 75, app. at 100.

[197] FED. COMMC'N COMM'N, *supra* note 41, at 79 ("[S]ome economists estimate that the consumer welfare gains from spectrum may be 10 times the private value to the spectrum holder."); *More Than Seven Dirty Words: Going Once,*

hold would put annual consumer surplus gains for an additional 45 MHz at about $2.4 billion per year. That would, per the FCC's proffered range of benefits, throw the Commission's cost-benefit conclusion into doubt. That doubt expands when one considers the faulty methods used, or additionally considers the rent-seeking costs (notably delay) omitted in rejecting a market-based bidding procedure – a delay-increasing approach, long noted.[198]

The FCC overlooked this economic evidence showing that not only do there exist "cognizable benefits" from an alternative path, but that they may well exceed the FCC's estimated valuation. That the FCC failed to incorporate this alternative indicates a fundamental mechanism design flaw.

VII. Policy Recommendation: Competitive Bidding for Rules

VII.1 Mandates for Unlicensed Lead to Rent Seeking Dissipation

The FCC's 5.9 GHz spectrum reallocation uses traditional "public interest" determinations. This method has the regulator inviting competing factions to put forward legal arguments, technical studies and economic analyses to guide the Commission in devising spectrum access rules that favor some applications at the expense of others. The Commission's expertise is used to discern truth from fiction, using comments and replies submitted in the proceeding to discern socially efficient rules and strategies for implementing the optimal regime. The process has been thoroughly critiqued, by experts inside and outside the agency. Overhead associated with this decision-making process includes:

(1) Inefficient delays,
(2) Wasteful investments by interests seeking transfers through favorable rules,

Going Infinitely, FED. COMMC'N COMM'N (Jan. 19, 2021), https://www.fcc.gov/news-events/podcast/going-once-going-infinitely [https://perma.cc/3WF4-DCGX] (statement of FCC economist Evan Kwerel) ("And then the $100 billion [raised in license auctions] doesn't even begin to capture the value to the consumers, and economists have estimated that the benefits to consumers are at least ten times as large as the amount of revenue raised, so that's, you know, $1 trillion."); *see also* Rosston, *supra* note 105, at 513; Hazlett & Muñoz, *supra* note 105, at 433.

[198] Harvey J. Levin, *Regulatory Efficiency, Reform and the FCC*, 50 GEO. L. J. 1 (1961) (Upon initiation, the auctions were evaluated as a substantial increase in social efficiency.).; EVAN KWEREL & WALTER STRACK, FCC, AUCTIONING SPECTRUM RIGHTS, (2001); *More Than Seven Dirty Words, supra* note 195; Hazlett & Michaels, *supra* note 132, at 427.

(3) Deterrence of future efficiencies, posed by rigid spectrum use rules,
(4) Fragmented property rights, encumbering market coordination, and
(5) Social losses imposed by administrative errors in determining highest and best use of spectrum resources.

These "shipping and handling costs" of the FCC's administrative allocation process are especially problematic because the cost-benefit calculations presented to arrive at the November 2020 reallocation Order were fatally flawed in multiple dimensions. By its stated procedures, the Commission acted to explicitly facilitate one set of applications while failing to consider essential possibilities for input substitution; the opportunity cost of the 75 MHz dedicated (in total) by fiat; the costs of the rigidities imposed by the rule regime selected; or the use of an alternative mechanism for coordinating the conflicts between ITS and Wi-Fi and, crucially but entirely omitted, 5G and other potential applications deploying 5.9 GHz airwaves.

Yet, an alternative policy mechanism that creates more transparent and flexible outcomes has already been developed, tested, and adopted elsewhere by spectrum regulators. Rather than administratively select applications, the Commission initiated auctions for assignments in 1994.[199] This reform eased frictions in awards. The policy change joined with an existing trend in the law which constituted an even more fundamental liberalization: flexible-use spectrum access authorizations, particularly in those licenses nominally allocated for mobile telephone services.[200] With broad definitions of the services to be offered and the technologies or business models legally deployed, permits convey wireless access rights analogous to private property in frequencies. These cede decisions over how to optimize across rival network or applications, mitigate interference, and share airwaves. The institution relies on competitive forces to mediate disputes, largely by coordinating activities and devices, pricing spectrum access, and organizing ownership structures.

One key impediment to the flow of spectrum to open market rivalry, despite considerable liberalization of the rights issued, is the administrative decision to mandate that allocations be licensed (whether traditional or liberal) versus unlicensed. There is strong political pressure (rent-seeking) for this imposition of administrative

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[199] Hazlett, *supra* note 38 (providing the contentious history of how auctions were initially rejected, and then finally adopted); *see also* Coase, *supra* note 150.

[200] *See* HAZLETT, *supra* note 17 (detailing the history of the liberalization process).

decision making to continue or expand.[201] The near decade-long campaign to pare the ITS band from 75 MHz to 30 MHz, with the residual awarded to Wi-Fi-type applications, may be seen as a model. In 2015, for instance, unlicensed spectrum advocates encouraged the FCC to "reframe the Commission's public interest analysis to stress the importance of unlicensed as equal to, not subordinate to, licensed spectrum."[202] This movement had a policy win codified in the 2018 Ray Baum's Act, where Congress announced a national policy to:

"[M]ake... available on an unlicensed basis radio frequency bands to address consumer demand for unlicensed wireless broadband operations."[203]

This policy statement was augmented with some specific instructions from Congress, including the requirement that the FCC release a national plan for unlicensed spectrum.[204] Perhaps sensing the problems inherent in rationing a free resource, Congress added its usual catch-all condition to FCC decisions: the release of unlicensed spectrum must be "reasonable" and "in the public interest."[205]

Yet that directive opens for a rent seeking competition, not only between licensed and unlicensed, but between rival non-exclusive rights regimes – as playing out in the 5.9 GHz band. As seen, untested claims for competing values are made, delays block transformations, and rent dissipation ensues. There are alternative environments for making such social choices.

VII.2. Mechanism Design to Support Trade Tested Betterment

Deirdre McCloskey builds on the simple idea of gains from trade to construct an impressive, over-arching theory of economic history – in particular, the causes of the Great Enrichment. She prefers to call her foundational notion, however, "trade tested betterment,"[206] the

[201] Christina Majaski, *Rent Seeking*, INVESTOPEDIA (Dec. 3, 2021), https://www.investopedia.com/terms/r/rentseeking.asp [https://perma.cc/2ELY-5NM2].
[202] HAROLD FELD, PUB. KNOWLEDGE, IB DOCKET NO. 13-213, at 1 (2015) (notice of Ex Parte).
[203] *See* Consolidated Appropriations (Ray Baum's) Act, 47 U.S.C. § 1507(b) (2018).
[204] *See id.* § 1507.
[205] *Id.* § 1507(b).
[206] DEIRDRE NANSEN MCCLOSKEY, BOURGEOIS EQUALITY: HOW IDEAS, NOT CAPITAL AND INSTITUTIONS, ENRICHED THE WORLD (2016) (As McCloskey has noted, this is not "Social Darwinism" but its reverse. Darwin's

distinguishing characteristic of which is that incentives for investment are aligned to encourage improved products and methods, while market selection separates success from failure. Competition among decentralized decision-makers provides the momentum for progress, with economic evolution governed by survivorship.

With the dispute over the 5.9 GHz band, however, policies block substantial sources of "trade testing." Entrepreneurs who believe that DSRC is over-consuming bandwidth, and that alternative deployments could better utilize some or all of the 75 MHz "Car Band" allocation, are not able to fund the relevant experiment. Instead, they must lobby legislators or regulators for a change in government policy. As three FCC economists wrote in a Commission paper:

""The allocation between licensed and unlicensed use... is based on the FCC's judgment, which in turn relies on information provided by interested parties who seek to use the spectrum. One method of reducing the incentive that parties have to exaggerate the value they place on a given regime involves creating a market for such rules."[207]

The proposal was then made (in 2008) for an auction process designed to weigh the relative bids for frequencies.[208] The set-up was intended to shift the competition for policy from lobbying and the submission of self-interested comments, reports, and legal briefs to a bidding process wherein claimants internalized risks. Bids would reflect actual, not just asserted, values. Experiments were run by the FCC to test the model.

The laboratory set-up was to auction rights to use a band of frequencies, with participants playing the role of bidders. Winners would, as in actual markets, realize financial gains so long as their expenditures were less than the economic value of the assets they won. Two types of bidders participated. Parties wishing to purchase exclusive rights, A = 1, 2, ... N_A, constituted the first group. Parties desiring that the band be used for non-exclusive, unlicensed access, B = 1, 2, ... N_B, formed the second. The auctioneer (FCC) compared bids from the exclusive bidders, with each A offer considered individually, against the sum of the B bids. The winning offer would then be determined either as the highest A bid = A^*, with the band allocated to licensed spectrum, or, should $\sum_1^N B > A^*$, the band would be allocated to unlicensed.

elucidation of biological adaption in the "theory of evolution" borrowed from economists' observation of evolutionary forces in markets.); *see also*
ALBERTO MINGARDI, HERBERT SPENCER (2011); MATT RIDLEY, EVOLUTION IS EVERYTHING: HOW NEW IDEAS EMERGE (2015).

[207] BYKOWSKY et al., *supra* note 61.

[208] *Id.*

The experiment was executed using standard methods developed in experimental economics, and tests results were obtained. They revealed a public goods problem. The pro-unlicensed (*B*) parties under-bid, revealing less of their total demand than rival (*A*) bidders.[209] This prevented efficient outcomes. The source of the problem was the incentive for free riding. The auction was designed to attract bids favoring non-exclusive access, but the benefits to be captured from the use of unlicensed spectrum (should the auction results favor such a deployment) would then be open to all parties under access rules determined by regulators. Bidders with financial interests in the unlicensed outcome would systematically discount their bids to reflect the probability that they would *not* enter the marginal bid (deciding the outcome of the entire auction). This allows such bidders to pursue (factoring into their bidding strategy) the most favorable outcome, which is to exploit their preferred spectrum allocation and to have other parties fund it.

Yet this externality problem is addressed by a straightforward structural improvement. FCC spectrum experts Evan Kwerel and John Williams, earlier advancing the basic approach of using market pricing to allocate unlicensed bands, proposed that the Commission "select a single entity to serve as an auction agent to participate on behalf of all incumbents in the band."[210] Yet, the agency need not supervise the selection, but merely allow partnerships – such as have already spontaneously formed with CMRS auctions.[211] Firms or coalitions favoring spectrum uses typified by the business models associated with unlicensed use would so define access rules: "a licensee or group of licensees [that would] charge manufacturers a fee for the right to produce and market devices to operate in that band."[212] This is one business approach, among others, to internalize benefits for band financiers. The FCC unlicensed allocation bidding experiment excluded this option by arbitrarily imposing non-exclusive use rights for all

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[209] *Id.*
[210] Evan Kwerel & John Williams, *A Proposal for a Rapid Transition to Markey Allocation of Spectrum* (FCC, OPP Working Paper No. 38, 2002).
[211] Jeremy Bulow et al., *Winning Play in Spectrum Auctions* tbl.1 (Nat'l Bureau of Econ. Rsch., Working Paper 14765, 2009) (SpectrumCo, one of the top three bidders in the FCC's AWS-1 auction in 2006, is an example. In procuring rights to licensed spectrum averaging about 20 MHz across the United States, the bidding group collected $2.5 billion in payments from its members (which it then paid to the U.S. Government), appropriating access rights among the partners. The process worked on a contractual basis and required no special policy measures.).
[212] Kwerel & Williams, *supra* note 209, at 31.

potential users, not simply those certified by the winning consortium.[213]

The one key policy change to enable such bidding to encompass "unlicensed" business models would aim at expanding (liberalizing) license rights. Specifically, build-out requirements imposed on license winners are non-neutral, as they favor traditional network carriers and discriminate against "plug 'n play" local area network services such as Wi-Fi. As has been previously recommended, these rules should be relaxed or eliminated to end the discrimination.[214]

A market-based approach to allocating spectrum is complicated by incumbency. The 1999 Order promulgated rules to favor DSRC, inducing investments by auto makers and related technology suppliers and creating reliance interests. There are, indisputably, political rigidities (imposing transaction costs) that require a transition policy to accommodate aspects of coordination not always of concern with respect to initial spectrum allocations. This is why, for instance, the FCC chose to reallocate TV Band frequencies with an innovative two-sided auction held in 2016-17.[215] Paying incumbent licensees to exit broadcasting, and funding channel switching costs for stations continuing to engage in terrestrial transmission, was thought necessary to mitigate opposition to the change in spectrum use despite the FCC's clear legal authority to do so.[216]

VII.3 Transitioning Property Rights

Competitive bidding reveals demands. Those demands quantify benefits and, by valuing opportunities to be outbid, costs.[217] But a fresh, unencumbered auction of 5.9 GHz spectrum rights, allowing bids from distinct interests favoring different flavors of licensed or unlicensed usage, is infeasible. Incumbency prevents rights from being appropriated by regulators, as the FCC found in reconfiguring the TV Band, where it nominally possessed legal authority to deny license renewals and reallocate spectrum in the "public interest." Yet, it instead chose to pay $12 billion to broadcast station owners to induce their cooperation, compensating exits and channel reassignments, to make

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[213] BYKOWSKY et al., *supra* note 61, at 11.
[214] Hazlett, *supra* note 17, at 319.
[215] FCC, *supra* note 41, at 81.
[216] Thomas W. Hazlett, *Efficient Spectrum Reallocation with Transaction Costs and Without Nirvana*, GEO. MASON UNIV. L. & ECONS. RSCH. PAPER SERIES NO. 14-16 (2014); Gregory L. Rosston & Andrzej Skrzypacz, *Reclaiming Spectrum from Incumbents in Inefficiently Allocated Bands: Transaction Costs, Competition, and Flexibility*, 45 TELECOMMS. POL'Y (2021).
[217] PAUL MILGROM, PUTTING AUCTION THEORY TO WORK (2004).

70 MHz of unencumbered spectrum available for CMRS licenses, which mobile carriers bid $20 billion for (funding the "incentive" payments to broadcasters) in Auctions 1001 and 1002 in 2016-17.

A mechanism can be designed, however, to protect incumbent rights and accommodate bids for alternative services under new use rules. One approach in the 5.9 GHz would endow interests associated with the applications favored under the extant regime, namely DSRC, with ownership rights.[218] This could be constructed as a consortium of stakeholders. In the unlicensed Personal Communications Services (U-PCS) band allocation made in 1995, the FCC created such an organization for Unlicensed Transition and Management, later called "UTAM, Inc."[219] The body had authority to charge a per unit license fee, paid by manufacturers of radio devices accessing U-PCS frequencies, and to use such revenues to pay incumbent users of the band to relocate. Voting members of the board of trustees included representatives from Alcatel, Avaya, Motorola, NEC America, Nortel Networks, SpectraLink and Toshiba.[220]

The policy objective is to design a mechanism that will protect incumbents' interests, but to also allow for disruptive use of the 5.9 GHz which may include new access – "spectrum sharing" – for Wi-Fi devices. The auction approach would vest owners of currently favored technologies and grant sufficient flexibility such that bidders seeking such disruption can express their demand to decision-makers motivated to internalize gains from innovation. In short, the expanded ownership rights bring social opportunity costs – ignored by market participants when rights are narrow and inflexible – to bear upon private decision makers not bound by the rigidities preventing fluid adjustments to demands originally unseen (or suppressed) by policy makers.

Suppose that a (for-profit or non-profit) consortium was created, the Automobile Spectrum Association (ASA), with ownership shares awarded proportionally to automakers based on new vehicle sales revenue in 2017.[221] Further suppose that the consortium was,

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[218] Of course, all such incumbency designations can be adjusted to reflect 2020 (or other) reforms.

[219] Unlicensed Personal Communications Services Devices in the 1920–1930 MHz Band, 75 Fed. Reg. 33220 (proposed June 11, 2010) (to be codified at 40 C.F.R. pt. 52).

[220] SANDY ABRAMSON, FCC, AMENDMENT OF THE COMMISSION'S RULES TO ESTABLISH NEW PERSONAL COMMUNICATIONS SERVICES: UTAM REPORT TO THE FCC, GEN DOCKET NO. 90-314 (2003).

[221] FED. COMMC'N COMM'N, AMENDMENT OF THE COMMISSION'S RULES REGARDING DEDICATED SHORT-RANGE COMMUNICATION SERVICES IN THE

gratis, transferred a liberal FCC license for use of 5850-5925 MHz. With stakeholders in the organization now subject to opportunity costs, the incentives would immediately bend the incumbents' interests towards transitioning. Financial rewards would lure the organization to economize on its use of 5.9 GHz, perhaps to 30 MHz or even less, and to sell rights to bidders interested in promoting Wi-Fi, 5G, or other use of the bandwidth. This would mimic the C-Band Coalition, a group of incumbent satellite licensees allocated use of 500 MHz of spectrum (3.7 to 4.2 GHz) and which petitioned the FCC for permission to organize such an auction. The suggestion, which was adopted (albeit in modified form) by the agency, required incumbent satellite users to reduce their footprint to 200 MHz (forty percent) of the initial allocation.[222]

Various incentives or conditions are plausible. The rights might be granted to the incumbent interest on stipulation that rights are auctioned by a certain time (say one year), perhaps offering at least the 45 MHz of the 5.9 GHz that petitioners sought the FCC to make available for Wi-Fi service. In the auction, ASA would itself be free to bid, but would also collect the winning bid(s) were others to emerge victorious. This would, as with payments made to TV station owners agreeing to help accommodate a transition in TV spectrum, attempt to align incentives of incumbents with those of maximizing agents exercising ownership rights.[223] Revenues to the private organization would be taxable (either at the consortium or the stakeholder level), but an implicit tax could be imposed on the auction by the FCC (specifying a split of revenues).

5.850-5.925 GHZ BAND (5.9 GHZ BAND), WT Docket 01-90 at 6, n.12 (2004) (The FCC explicitly sought to aid this sector in allocating the ITS band in 1999. The link to industry has been formalized by ITS America, described by the Commission: "ITS America, a Federal Advisory Committee to DOT, was first organized in 1991 and is a non-profit, educational association. Its members are drawn from the business, academic, and government sectors. ITS America has over 600 members. Over 350 of its members represent corporations involved in providing transportation of goods and services, 135 members represent federal, state, and municipal transportation agencies, and fifty members represent research institutions and universities.).

[222] Press Release, FCC, FCC Announces Winning Bidders in C-band Auction; Auction 107 of 3.7 GHz Service Licenses Yields Over $81 Billion in Gross Bids and Provides Much-Needed Mid-Band Spectrum for 5G Services (Feb. 24, 2021).

[223] Dorothy Robyn, *The Unfinished Business of Transportation Deregulation*, 315 TR NEWS 49, 51 (2018) (Transportation Research Board, National Academy of Sciences) (Air traffic control (ATC) facilities in over thirty countries (but not the U.S.) have been spun off from government agencies, using to non-profit organizations owned by a consortium of aviation stakeholders. NAV Canada, one notable example, has achieved notable efficiencies in managing airports and traffic control.).

This mechanism is cryptically described. Numerous variations are possible. The pathway is not so vague, however, as considerable experience has been gained by reformers who have managed, over decades, to liberalize spectrum use. The central achievement has been to allow spectrum input prices to be revealed, with such information incentivizing allocation choices. The transfer of control from administrative process to market experimentation has richly evolved to incentivize incumbent interests, and prospective bidders, to reveal and embrace actual values is a crucial contribution.[224] It has been shown to support efficient reconfigurations of radio spectrum use, and to dramatically speed the pace at which innovation in moribund radio bands have sprung back to life. As the FCC has noted: "In general, a voluntary approach that minimizes delays is preferable to an antagonistic process that stretches on for years."[225]

VIII. Conclusion

In 1999, the FCC confidently predict that 75 MHz of radio spectrum in the 5.9 GHz band would be best utilized by walling it off for advanced automobile communications:

"By this action, we allocate 75 megahertz of spectrum at 5.850-5.925 GHz to the mobile service for use by Dedicated Short Range Communications ("DSRC") systems operating in the Intelligent Transportation System ("ITS") radio service. ITS services are expected to improve traveler safety, decrease traffic congestion, facilitate the reduction of air pollution, and help to conserve vital fossil fuels. DSRC systems are being designed that require a short-range wireless link to transfer information between vehicles and roadside systems."[226]

In 2004, after petitioners suggested that applications like Wi-Fi be allowed to share the "Car Band," regulators dispatched the notion:

"Most commenters *oppose unlicensed operations under Part 15* [as apply to Wi-Fi services] for any DSRC-based ITS application… The Alliance of Automobile Manufacturers argues against unlicensed operations, stating that radio frequency interference from unlicensed devices and their noncompliance with channel controls and the

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[224] Matthew Lasar, *Congress Goes After Unlicensed Wireless "Free Riders" (Like Google and Microsoft)*, ARS TECHNICA (July 14, 2011, 5:08 PM), https://arstechnica.com/tech-policy/2011/07/republican-spectrum-bill-reins-in-wireless-free-riders-like-google/ [https://perma.cc/QD8J-28XV] (Proposed legislation to mandate that the FCC conduct auctions for licensed and unlicensed allocations, with high bids resulting awards (taking the usage model out of FCC discretion and moving it into competitive determination) was advanced (but not introduced) by members of the U.S. Congress in 2011.).

[225] FED. COMMC'N COMM'N, *supra* note 41, at 79.

[226] FED. COMMC'N COMM'N, *supra* note 76, ¶1.1.

message prioritization framework would undermine the projected effectiveness of vehicle safety enhancements made possible by DSRC… putting lives and property unnecessarily at risk."[227]

Ten years later, when the idea of Wi-Fi use of 5.9 GHz was again formally addressed, regulators advised the rival parties to just get along:

"With respect to the 5850-5925 MHz band, instead of expending resources on traditional interference analysis that would certainly show the potential for harmful interference to other authorized users of Dedicated Short-Range Communications (DSRC) systems, NTIA encouraged U-NII device manufacturers and representatives of the automobile industry to consider ways for their technologies to be interoperable, work cooperatively, or otherwise coexist with each other. NTIA continues to monitor discussions between auto industry and U-NII stakeholders in a working group of the Institute of Electrical and Electronics Engineers (IEEE) 802 standards committee."[228]

But not everyone did get along. Hence, in 2020, the FCC adopted a new policy, mandatorily shifting 45 MHz to support Wi-Fi, leaving 30 MHz set aside for ITS. In this long and winding policy pathway, little to nothing of value – by the FCC's own admission – has yet to occur. Twenty years of administrative process, voluminous proceedings and dueling regulatory filings, comments and sponsored studies, and yet unoccupied bandwidth still dominates.

Indeed, the rent-seeking in the 5.9 GHz is not officially over. After the FCC's Order was issued, interests opposed to the decision prompted Congressional involvement. In March 2021, the Chair of the House Transportation and Infrastructure Committee, Peter DeFazio (D-OR), took the initiative to attempt to re-open the regulatory matter. In a letter to the Acting Chair of the FCC, Jessica Rosenworcel, he wrote:

"I am writing to express my continued strong opposition to the Federal Communications Commission's (FCC) decision to shar the 5.9 GHz radio frequency band (or Safety Band) with unlicensed WiFi… The FCC's decision ignored the safety concerns raised by FOT, bipartisan opposition from 38 members of Congress, every state Department of

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[227] FED. COMMC'N COMM'N, *supra* note 72, ¶65.
[228] NAT'L TELECOM. & INFO. ADMIN., FOURTH INTERIM PROGRESS REPORT ON THE TEN-YEAR PLAN AND TIMETABLE AND PLAN FOR QUANTITATIVE ASSESSMENTS OF SPECTRUM USAGE 15 (2014).

Transportation in the nation, and the entire transportation stakeholder community."[229]

Shortly thereafter, two transportation organizations filed suit against the FCC Order, seeking to undo it on the grounds that the Commission has ignored or misread the evidence, exceeded its authority, and failed to properly incorporate the expert input of U.S. transportation officials. The plaintiffs were a private non-profit organization, Intelligent Transportation Society of America, composed of local (public) agencies and private companies including automakers and the American Association of State Highway and Transportation Officials (AASHTO), made up of state transportation boards in all fifty states.[230] As described in the trade press, the suit alleged that the Department of Transportation "was on the record as having said the FCC substituted its judgment for that of transportation safety stakeholders, which was that they needed the full 75 MHz of the 5.9 GHz band for ITS systems that make the road safer. [231] The suit is yet to be resolved.

The real tragedy of 5.9 GHz is not that regulators did not see the future, but that they now so little understand the past. In rejecting the specific application that for two decades has eluded them, FCC policymakers confidently shifted the Car Band – in part – to a different allocation, using precisely the same procedural approach that had failed them for two decades. The recently adopted reforms will succeed or fail based only on how well FCC decisions anticipate costs and benefits in the years to come. Policy makers create and choose among "cost benefit" studies that ignore substitution effects, use inapt proxies for valuing services, deny the existence of opportunity costs (save those conveniently posing no "cognizable benefits"), exclude administrative and rent seeking costs, and ultimately make net benefit claims for reallocations that will not be verified by responsible parties. No residual claimant will benefit were the predictions to be true, and no spectrum decision maker will lose should their choices prove socially expensive.

The quest for policy is to design mechanisms the police this equilibrium, implementing improved institutions with feedback loops

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[229] Letter from U.S. Rep. Peter D. DeFazio, Chair of the Comm. on Transp. & Infrastructure, to the Hon. Jessica Rosenworcel, Acting Chairwoman, FCC (Mar. 18, 2021).

[230] *Intel. Trans. Soc'y of Am. v. Fed. Commc'ns. Comm'n*, 45 F.4th 406 (D.C. Cir. 2022).

[231] John Eggerton, *FCC Transportation Stakeholders Square Off in Court Over 5.9 GHz Spectrum*, MULTICHANNEL NEWS (Jan. 25, 2022), https://www.nexttv.com/news/fcc-transportation-stakeholders-square-off-in-court-over-59-ghz-spectrum [https://perma.cc/T94Y-4K5X].

that steer towards rational economic choices. The decades long waste of valuable airwaves does not achieve that. The continued decision-making by actors who internalize none of the economic outcomes is a design flaw.

Beyond the preliminary policy suggestion for transition by auction, the analysis of the rent seeking competition in the 5.9 GHz band can be highly instructive. It combines public choice with law and economics, as new property rights are the subject of a rivalrous process. Rent seeking dissipation occurs without the prospect of exclusive rights; competitive for preferred regimes favoring particular economic interests proceed apace. The long delays associated with defining valuable rights, caused by "lock-ins" that block the adoption of emerging technologies, are properly the concern of public policy. Moving towards a spectrum allocation regime that better reveals the available opportunities, usefully prioritizes them, and expeditiously embraces them, has historically produced substantial gains. The rent seeking saga in the 5.9 GHz band demonstrates that not all sources of progress have been exhausted.