

# A Case for Property Rights in the Electromagnetic Spectrum

How Private Markets Can Unleash Telecommunications Innovation

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*By Ryan Radia and Joseph Kane*

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### Executive Summary

The air that surrounds us may appear empty, but it is full of information that travels across waves of electromagnetic frequency. Although we can see some of these frequencies—which we perceive as light—most of the electromagnetic spectrum is invisible to the naked eye. The imperceptible signals that traverse this spectrum make it possible for us to pinpoint our location using satellites and allow airline pilots to communicate with air traffic controllers hundreds of miles away. These signals also enable television antennae to receive video transmitted from local broadcasting stations. Spectrum is the medium by which our laptop computers and smartphones send and receive information wirelessly over the Internet. Simply put, life in the 21<sup>st</sup> century revolves around technology—and, in turn, technology revolves around spectrum.

We are surrounded by spectrum, but it is not a limitless resource. In a finite space, spectrum has the capacity to carry only so much information, while different frequencies—wavelengths—vary in their ability to travel long distances and penetrate buildings, trees, and weather. Although advances in technology have enabled spectrum to be used more efficiently, fitting more information into a smaller spectral footprint, demand for spectrum often outstrips available supply.

Deciding who will use spectrum and how matters a great deal in determining the extent to which consumers can enjoy the benefits of wireless communication. When no one has the right to exclude any other person from using a particular frequency, spectrum is likely to be overused, as everyone seeks to maximize his or her benefit from the airwaves without

regard to the consequences for others. Conversely, when spectrum is restricted to users who are unable to make the most of their transmissions—or transfer their spectrum to those who can—the resource is likely to be underused. Underuse can be just as costly as overuse as it results in idle spectrum that someone could use productively.

This paper reviews the historical use of spectrum, including how governments have sought to oversee and regulate it. It then discusses how spectrum policy in the United States has adapted to technological evolution over the past century. Finally, it suggests how policy makers can achieve tremendous welfare gains by allocating spectrum through voluntary, decentralized markets.

Distributing the rights to use spectrum via markets incentivizes private holders of those rights to make efficient use of their spectrum and to invest and innovate in ways that increase the overall capacity of spectrum to facilitate the use of wireless devices. If a firm can lease excess spectrum to others, this will encourage it to make efficient use of its spectrum because it can profit from leasing out what it does not use.

Market distribution of spectrum also incentivizes innovation because inventing new protocols or more accurate sensors could reduce the amount of spectrum needed for an owner's current use, and it can profit from leasing out the excess or adding additional customers. In short, the price system will accommodate changes in demand for spectrum.



## Introduction

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## A History of Spectrum in the United States

In the United States, the federal government has regulated the airwaves for as long as they have been a useful

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medium of communication. Early in the 20<sup>th</sup> century, the Department of Commerce was responsible for regulating domestic radio transmissions, while the U.S. Navy oversaw uses of the airwaves on the high seas.<sup>1</sup> Economist and Nobel laureate Ronald Coase recounts Secretary of the Navy Josephus Daniels’s description of the situation: “There is a certain amount of ether, and you cannot divide it up among the people as they choose to use it; one hand must control it.”<sup>2</sup> An advisor to Secretary Daniels went further, contending that “radio, by virtue of the interferences, is a natural monopoly; either the government must exercise that monopoly by owning the stations, or it must place the ownership of these stations in the hands of one concern and let the government keep out of it.”<sup>3</sup> Although the Navy did not end up in charge of spectrum, the notion that the government should strictly manage the airwaves would long remain a central assumption in spectrum policy—and it persists to this day.

As radio grew in popularity and national importance during the 1920s, Congress passed the Radio Act of 1927, empowering a five-member Federal Radio Commission to oversee the granting of broadcast licenses and the assignment of frequencies.<sup>4</sup> Seven years later, at the urging of President Franklin D. Roosevelt, Congress passed the landmark Communications

Act of 1934,<sup>5</sup> which created the Federal Communications Commission (FCC) to replace the Federal Radio Commission and gave the new FCC broad powers over both wireline and wireless telecommunications, including radio communications.<sup>6</sup> This law, as amended, remains intact today, and the FCC continues to oversee spectrum allocation in the United States.<sup>7</sup>

For most of the FCC’s history, licensing broadcast stations and policing the contents of their transmissions were among the agency’s highest priorities.<sup>8</sup> According to one longstanding rationale for government control of the airwaves, because spectrum is scarce, it can be responsibly allocated only by the government—and not by the marketplace. During the 20<sup>th</sup> century, an array of laws, judicial decisions, and FCC determinations all treated spectrum as a regulated commodity because, they held, it was a uniquely scarce resource. Justice Felix Frankfurter articulated this view in writing the Supreme Court’s majority opinion in the 1943 case of *NBC v. United States*:

But the [Communications] Act does not restrict the Commission merely to supervision of the traffic. It puts upon the Commission the burden of determining the composition of that traffic. The facilities of radio are not large enough to accommodate all who wish to use them. ... Since the

very inception of federal regulation by radio, comparative considerations as to the services to be rendered have governed the application of the standard of “public interest, convenience, or necessity.”<sup>9</sup>

Despite the popularity of this approach among lawmakers, in hindsight, entrusting federal bureaucrats with the power to dictate how spectrum is used has not led to an ideal allocation of this resource. Yet the wisdom of this policy went largely unquestioned for decades. It was not until economist Ronald Coase published his seminal paper, simply entitled “The Federal Communications Commission,” in 1959 that a different method of managing spectrum would emerge.<sup>10</sup>

Coase observed that scarcity is ubiquitous; resources such as steel, land, food, and oil all exist in finite quantities at any given point in time.<sup>11</sup> The fact that spectrum is scarce is thus not a unique quality. The field of economics—famously defined by the British economist Lionel Robbins as “the science which studies human behavior as a relationship between ends and scarce means which have alternative uses”<sup>12</sup>—has long recognized that market prices are often the best way to convey information about the relative scarcity of an asset so that it can be put to its most highly valued use. Nevertheless, for much of the

20<sup>th</sup> century, policy makers imposed rigid economic regulation in many important network industries, including telecommunications, railroads, trucking, aviation, and electricity, among others.

A related rationale for government control of spectrum is the mitigation of “harmful interference” between signals on adjacent frequencies or in nearby geographic areas.<sup>13</sup> Yet, that is neither unique to spectrum nor an adequate justification for strict federal micromanagement. Moreover, avoiding harmful interference at all costs is a misguided objective. Public policy should instead seek to maximize the social benefit of the airwaves, which means searching for the optimal level of interference.<sup>14</sup> That entails mediating spectrum disagreements in a way that provides for efficient dispute resolution without placing excessive obstacles on the development of innovative uses of spectrum. It also requires weighing the interests of newcomers against those of incumbents, instead of according absolute protection to the first user.<sup>15</sup>

In general, when government involvement is necessary to resolve property disputes, they are most effectively addressed under simple and general rules applied on a case-by-case basis.<sup>16</sup> For instance, when a court hears a dispute between a landowner and an alleged trespasser, both of whom may present their side of the story in an adversarial proceeding

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before an impartial judge (and, in some cases, a jury). The court makes a determination of wrongdoing and, if appropriate, awards the injured party monetary damages and other relief. Many doctrines and standards—some with roots in English or even Roman law—influence how courts decide property disputes. But these factors tend to be flexible, evolving over time in response to social change and technological progress.

Regulatory regimes, by contrast, usually entail proscriptive *ex ante* mandates in the form of rules, memoranda, and guidance documents. Decision making is typically centralized, often overseen by ambitious political appointees eager to curry favor with the media and susceptible to “capture” by powerful incumbent industries.<sup>17</sup> Legal scholars have criticized the constitutionality of the modern administrative state and its usurpation of common-law courts in many areas, but upholding the Framers’ vision of government is not the only reason to restore the role of the judiciary in resolving disputes involving property interests.<sup>18</sup>

To the extent that courts are less biased and more politically independent than administrative agencies, judicial resolution of disputes is likely to produce superior outcomes compared to agency rulemaking or adjudication.<sup>19</sup> It is no coincidence that when Congress

passed legislation in the 1970s and 1980s to deregulate industries such as aviation and trucking, efficiency and consumer benefits in those markets increased.<sup>20</sup> Similarly, moving toward judicially supervised property rights in spectrum could prove a boon for consumers.<sup>21</sup>

### **Spectrum Policy since Coase**

Although Ronald Coase’s call for rethinking spectrum policy in 1959 was well-received among economic scholars, the process for allocating the airwaves changed little in the decades that followed. Thirty-five years later, after receiving new orders from Congress, the FCC conducted the nation’s first spectrum auction in 1994. Lawmakers were finally persuaded to give Coase’s proposal a shot, in large part by the prospect of generating revenues by means other than taxation. The winners of a spectrum auction must pay a sum to the federal government that ends up in the Treasury Department’s general fund.<sup>22</sup> About 100 auctions have occurred since 1994,<sup>23</sup> garnering over \$100 billion in payments from auction winners.<sup>24</sup>

However, to this day, the FCC continues to meddle with spectrum auctions whenever it has a chance, wielding its nebulous “public interest” standard as an excuse for imposing the policy preferences of the majority of the

agency's five commissioners.<sup>25</sup> For example, the Commission has distorted the price mechanism by creating a "designated entity" program aimed at favoring small businesses that participate in spectrum auctions by giving them discounted bids. In practice, however, designated entity programs have done little to benefit small business while enriching sophisticated and established market participants—and thereby depriving society of the welfare gains of optimizing spectrum use. For instance, in the recent AWS-3 auction, DISH Network, a satellite communications provider with annual revenues exceeding \$14 billion, took advantage of the FCC's auction rules by partnering with smaller affiliated companies to win discounted spectrum licenses worth \$3.4 billion. Although the company's affiliates later returned these licenses, this came after a costly investigation and a prolonged legal battle.<sup>26</sup>

The FCC also impedes the functioning of the price mechanism through the structure of the licenses it elects to put up for auction. As former FCC Chief Economist Thomas Hazlett has noted, the Commission's current rules "go far beyond the delineation of boundaries between users, restricting technologies, power, transmitter locations, business models, and services." Thus, Hazlett argues, the term "spectrum auction" is "misnomer"—the price system is used to assign operating licenses that restrict

the use of radio spectrum to a specific, regulated use.<sup>27</sup>

Consequently, Hazlett explains, spectrum has suffered from a phenomenon known to economists as the "tragedy of the anticommons."<sup>28</sup> Whereas a traditional "tragedy of the commons" entails inadequate property rights resulting in the *overuse* of a scarce resource, the analogous anti-commons tragedy occurs when property rights in a particular resource become too numerous or fragmented such that it is *underused*.<sup>29</sup> This "commons" scenario is perhaps better described as "open access," given that a "commons" is generally defined as any resource controlled jointly by a group of individuals subject to restrictions on who may use it and how.<sup>30</sup>

With respect to spectrum, the FCC's insistence that certain bands may only be used for specific services using particular technologies or business models has meant that the rights for sale at auction are too rigid to facilitate dynamic technological change. Spectrum bands can thus remain unutilized even though they are immediately adjacent to other bands being put to productive use. Rigid licenses make it costly for potential users of the airwaves to aggregate viable portfolios of spectrum and put them to productive use. Society suffers the opportunity cost of this underuse,

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losing out on productive activity that would have taken place if the spectrum in question had been more efficiently allocated. Overall, this rigidity has produced enormous losses for consumers and for the economy as a whole.

### **How Government and Legacy Licensees Squander Spectrum, to Entrepreneurs' and Consumers' Detriment**

The 100 spectrum auctions conducted by the FCC since 1994 have focused on reallocating bands of spectrum previously used by the private sector, such as television broadcast stations. Yet a massive portion of the spectrum is reserved for the use of departments and agencies of the U.S. government. Some 60 percent of the spectrum is assigned, either on a shared or exclusive basis, to federal government entities.<sup>31</sup> Among these bands are much of the so-called “beachfront” spectrum<sup>32</sup>—frequencies between 300 MHz and 3 GHz—which are the most economically valuable due to their ability to carry considerable quantities of data over dozens of miles.<sup>33</sup>

Comprehensive reform of the spectrum allocation system must address how the federal government uses—or, in many cases, misuses—spectrum. The government’s use of spectrum is administered not by the FCC but by

the National Telecommunications and Information Administration (NTIA), within the Department of Commerce. By informal arrangement, the FCC and NTIA jointly determine whether a particular band of spectrum is allocated to private or government use, subject to various legislative mandates.<sup>34</sup> Each federal department or agency can only use the spectrum assigned to it by the NTIA.<sup>35</sup>

While government entities from the military to public safety agencies use spectrum in many important ways, the economic incentives that agencies face are fundamentally different from those faced by private firms. Government agencies do not “pay” for their spectrum at auction, or in any other manner, and hence have little reason to conserve their use of spectrum when it might be more fruitfully used by companies serving consumers—or by other agencies.

Worse, agencies often have an incentive *not* to efficiently use the spectrum allocated to them, because budgets are tight and squeezing the most out of a finite pool of spectrum often entails purchasing costly devices and facilities.<sup>36</sup> Thus, using spectrum inefficiently is often more cost-effective to an agency than the alternative, given that the agency has little to gain by ceding some of its spectrum to the commercial marketplace, or to another agency.

The status quo not only favors government users, it distorts the wireless marketplace and produces inefficiencies that have real negative effects on consumers. To the federal agencies that use spectrum, it is extremely underpriced. This distortion translates into artificially higher wireless bills for consumers and impedes innovation in wireless technologies. Although private auctions for smaller bands of spectrum often bring in tens of billions of dollars, total federal fees paid in connection with controlling over half of beachfront spectrum totaled a mere \$30 million in 2012.<sup>37</sup> In February 2014, the FCC's auction of just 65 MHz in the AWS-3 bands generated over \$41 billion in revenues.<sup>38</sup>

The more it costs a private company to acquire a spectrum license, the fewer new inventions will come to market in the first place. Harnessing the price mechanism as a means of rationalizing how federal agencies use spectrum is essential to reforming the spectrum allocation process as a whole.

Unleashing the now restricted supply to be used where it is valued most would be a boon to consumers and innovators alike.

Government agencies should not continue to use spectrum without facing its market price. In general, when an agency wishes to procure a resource, it must budget for such

an expenditure and obtain the appropriations to actually spend government funds. For instance, when federal agencies need to occupy land or buildings, they lease such property from the General Services Administration (GSA). The right to transmit over spectrum is likewise a scarce resource and can be allocated in the same way. Oversight of federal spectrum should be vested in an agency that is endowed with authority over all federal spectrum—as the GSA is with federally owned properties—including the power to lease it out to agencies in return for appropriated funds.

The government arguably controls too much spectrum, although a more complex analysis is necessary to determine exactly how much spectrum should be allocated to GSA-style management. The prices that agencies face will fluctuate over time as they bid against other agencies—and against market participants—for the right to transmit over particular frequencies and in particular places. But this is no reason to worry that essential government functions will run short on spectrum, as government agencies are free to participate in the marketplace to acquire spectrum—just as agencies already do for other resources, from pencils to rifles.

In fact, the GSA-style bank of spectrum rights may eventually become obsolete, or at least much less relevant, as

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technological developments change the nature of spectrum availability and use. In general, a particular spectrum holding is defined by a signal's allowable location, time, frequency, and direction of arrival.<sup>39</sup> Technologies such as low-power transmitters and mesh networks have altered the relative importance of these dimensions over time.<sup>40</sup>

Congress recognized the importance of transferring federal spectrum to the private sector when it passed the 2004 Commercial Spectrum Enhancement Act. This law provides for a Spectrum Relocation Fund designed to compensate federal agencies for the costs they incur in transitioning to a more modest spectrum footprint.<sup>41</sup> However, until recently, this law imposed significant constraints on which agency expenses were eligible for compensation.<sup>42</sup> And despite repeated proclamations from senior government officials that repurposing federal spectrum is an urgent priority, the process of freeing up such spectrum has moved extremely slowly.<sup>43</sup> The proposal we describe above would build on existing legislation to speed up the process of migrating spectrum from government entities to the marketplace.

As noted, the opportunity cost of spectrum misallocation is extraordinary. Bureaucratic inefficiencies should not trump the interests of American consumers, who stand to gain

considerable surplus if spectrum were more intelligently allocated among governmental and private users.

### **Beyond FCC Licenses: A Case for Spectrum Ownership**

The core principle of our proposal to reform spectrum allocation is that it should be treated like an ordinary economic resource such as food, coal, or land. Coase articulated this concept as follows:

[W]hat is being allocated by the Federal Communication Commission, or, if there were a market, what would be sold, is the right to use a piece of equipment to transmit signals in a particular way. Once the question is looked at in this way, it is unnecessary to think in terms of ownership of frequencies or the ether.<sup>44</sup>

We propose allowing individuals and firms to own an exclusive right to transmit and receive information via specified frequencies of radio waves bounded by a specified geographic area.<sup>45</sup>

We recommend the creation of a property right based on the model described by Thomas Hazlett, who coined the term “exclusively assigned, flexible use spectrum.”<sup>46</sup> The possessor of exclusive permission to use such spectrum would hold a property right that is “good against the world,” as

opposed to enforceable merely against persons who have agreed to respect the spectrum assignment.<sup>47</sup> This regime would supersede the status quo.

Currently, the FCC regulates spectrum licenses, with owners of spectrum interests allowed to operate within particular bands in perpetuity, free from governmental restrictions on the content they transmit, provided that it would not otherwise run afoul of applicable statutes or common law principles.<sup>48</sup> These rights should be transferrable and divisible at their owners' discretion. In other words, public policy should allow spectrum owners to avail themselves of the panoply of ownership arrangements available to owners of personal and real property.<sup>49</sup>

This shift in policy could be implemented for private spectrum users through a federal statute providing that existing exclusive spectrum licensees will, as of some specified date, hold an ownership interest in the spectrum to which they are assigned. This straightforward approach would establish an ownership regime with respect to a considerable portion of the available spectrum without necessitating that the FCC reassign licenses via an auction or some other regulatory maneuver.

As for the inefficiencies that would result from this initial allocation of spectrum, newly minted owners of spectrum interests would be free to

sell or lease their rights in particular frequencies to other private or public users. Existing spectrum users eager to expand their use of the airwaves would move quickly to make offers to potential sellers or lessors of spectrum interests, while capital markets would respond to this potential reallocation of spectrum by fueling ventures to acquire spectrum that are expected to generate economic profits. Specialized entities that aggregate, repackage, and sell spectrum portfolios would also likely emerge, helping reduce the transaction costs inherent in reshuffling a complex regime of property rights from a relatively inefficient allocation to a more efficient one.

As for disputes among spectrum owners, allowing them to seek traditional forms of judicial relief based on common law principles when interference occurs would likely produce superior resolutions to interference disputes than bureaucratic deliberation. From preliminary injunctive relief to awarding money damages after wrongful interference is found to have taken place, the legal system has developed a set of rules to govern property disputes that is fully capable of adjudicating claims of spectrum interference.

Unlike past spectrum auctions, the simple recognition of spectrum ownership interests held by current licensees would mean that the government could not skim tens of

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billions of dollars off the reallocation of spectrum. Politicians might not be enamored of this “sacrifice,” but generating revenues for the federal government should not be the purpose of spectrum allocation. Migrating spectrum to better uses quickly and efficiently is the best recipe for galvanizing economic growth, and, in turn, tax receipts. Mitigating the large opportunity costs of inefficient use and maximizing the productive capacity of spectrum will yield lower prices for consumers to use modern devices, and provide a healthy landscape for innovation and efficiency gains that will sustain and push the wireless ecosystem into the future.

These benefits are not only theoretical. There is empirical evidence available from the limited bands in which the FCC has permitted exclusive and flexible licenses. Hazlett’s 2004 analysis of bands used for commercial mobile radio service (CMRS)—devices such as cell phones in which exclusive licenses were issued—yields a conservative estimate of \$81 billion in consumer surplus per year.<sup>50</sup> That estimate is from 2005, before the unveiling of the Android operating system or the iPhone, so the number is surely much higher now. These bands saw greater degrees of sharing, efficiency, investment, and productivity.<sup>51</sup> Investment in these bands has included physical infrastructure buildouts such as

307,626 cell sites and monetary capital investments of \$32 billion in 2015.<sup>52</sup>

Hazlett and Roberto Muñoz analyze the consumer impact of making additional spectrum available for CMRS use. Their analysis suggests that, on average, each additional 60 MHz made available for CMRS uses increases consumer surplus by over \$60 billion annually.<sup>53</sup> That estimate was in 2004, again before the advent of the iPhone. The proliferation of smartphones and other wireless devices has helped make spectrum even more valuable to consumers today. According to a 2015 study, the present value of consumer surplus of the roughly 650 MHz of licensed spectrum in the United States is between \$5 trillion and \$10 trillion.<sup>54</sup> This also means that the opportunity cost of inefficient allocation is greater than ever.

Another alternative that has been proposed is to sunset restrictive licenses as they expire. These could then be auctioned as exclusive assets to owners who would hold them in perpetuity. This would generate substantial government revenue and may be more politically palatable, but would also prolong the costs of existing inefficiencies in spectrum allocation. And this alternative might implicate the Constitution’s Takings Clause, which some broadcasters have claimed prevents the government from

depriving them of their spectrum licenses without just compensation.

## **Conclusion**

The benefits of liberalizing spectrum under a regime of property rights are derived from the essential characteristics of exclusivity of access and flexibility of use that are often lacking under the current system.

Exclusivity solves the tragedy of the commons issues associated with open access in unlicensed bands, by affording an identifiable entity the right to determine the rules by which a particular spectrum holding may be used. Such exclusivity need not entail significantly greater restrictions than status quo unlicensed bands, as a spectrum holder might wish to maximize the benefit of its portion of the airwaves by imposing relatively few restrictions on the devices and types of communications that may traverse its spectrum.

For certain uses of spectrum, holding exclusive nationwide rights over a wide frequency range is necessary to offer the most robust connectivity at

the lowest cost. Flexibility enables the assembly of sufficiently broad spectrum holdings to satisfy consumer demand for such uses, as it removes the anticommons tragedies associated with spectrum use restrictions that complicate the aggregation of such holdings.

Distributing the rights to use spectrum via markets, rather than through FCC bureaucracy, incentivizes private holders of those rights to make efficient use of their spectrum and to invest and innovate in ways that increase the overall capacity of spectrum to facilitate the use of wireless devices. If a firm can lease excess spectrum to others, this will encourage it to make efficient use of its spectrum because it can profit from leasing out what it does not use.

Market distribution of spectrum also incentivizes innovation because inventing new protocols or more accurate sensors could reduce the amount of spectrum needed for an owner's current use, and it can profit from leasing out the excess or adding additional customers. In short, the price system will accommodate changes in demand for spectrum.

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## NOTES

- 1 Radio Act of 1912, ch. 287, 37 Stat. 302.
- 2 Ronald Coase, “The Federal Communications Commission,” *The Journal of Law and Economics*, Vol. 2 (1959), p. 3, <https://people.eecs.berkeley.edu/~dtse/coase.pdf>.
- 3 *Ibid.*, p. 4. The adviser did not explain why the presence of interference makes spectrum a “natural monopoly,” a term that economists use to describe a market in which one firm can supply the industry with “one commodity at a cost lower than it can be done by any two or more enterprises.” William J. Baumol, “Contestable Markets and the Theory of Industry Structure,” *American Economic Review*, Vol. 72, No. 1 (1982), p. 12.
- 4 Radio Act of 1927, Ch. 169, 44 Stat. 1162.
- 5 Act of June 19, 1934, Ch. 652, 48 Stat. 1064 (codified as amended at scattered sections 47 U.S.C.) (“Communications Act”).
- 6 Communications Act, title III, 47 U.S.C. §§ 301 et seq.
- 7 In general, the FCC is empowered to assign frequencies, “prescribe the nature of service” rendered by spectrum licensees, and regulate the devices used to transmit or receive radio frequencies. 47 U.S.C. § 303.
- 8 Note, “Old Standards in New Context: A Comparative Analysis of FCC Regulation,” *University of Chicago Law Review*, Vol. 18, No. 1 (1950), p. 83, <http://chicagounbound.uchicago.edu/cgi/viewcontent.cgi?article=2648&context=uclrev>.
- 9 319 U.S. 190, 215–17 (1943).
- 10 Coase.
- 11 *Ibid.*, pp. 14, 18–19.
- 12 Lionel Robbins, *An Essay on the Nature and Significance of Economic Science*, (London: Macmillan, 1932) p. 16.
- 13 See, for example, 47 U.S.C. § 302a, which empowers the FCC to “make reasonable regulations” governing devices capable of emitting radio frequency to prevent “harmful interference to radio communications.”
- 14 Coase, p. 27. For an extended discussion of public policy, welfare, and output, see Joshua D. Wright and Douglas H. Ginsburg, “The Goals of Antitrust: Welfare Trumps Choice,” *Fordham Law Review*, Vol. 81 (2013), p. 2405, [https://www.ftc.gov/sites/default/files/documents/public\\_statements/goals-antitrust-welfare-trumps-choice/130320goalsofantitrustbp4.pdf](https://www.ftc.gov/sites/default/files/documents/public_statements/goals-antitrust-welfare-trumps-choice/130320goalsofantitrustbp4.pdf).
- 15 Under the law of nuisance, developed over time by the courts, an intentional non-trespassory invasion of another person’s interest in real property is evaluated based on the gravity of the harm, the degree to which it affects the property owner, and the utility of the conduct giving rise to the invasion. *Restatement (Second) of Torts* § 826 (1979).
- 16 Neighbors regularly resolve disputes over property and other matters without seeking recourse from the government, influenced by social norms and reputational incentives. Robert Ellickson, *Order without Law* (Cambridge, Massachusetts; Harvard University Press, 1991).
- 17 George Stigler, “The Theory of Economic Regulation,” *Bell Journal of Economics and Management Science*, Vol. 2, No. 1 (1971), p. 3.
- 18 This argument has been advanced by scholars including Philip Hamburger in *Is Administrative Law Unlawful?* (Chicago: University of Chicago Press 2014) and Richard Epstein in “Why the Modern Administrative State Is Inconsistent with the Rule of Law,” *NYU Journal of Law & Liberty*, vol. 3 (2008), p. 491, [http://www.law.nyu.edu/sites/default/files/ECM\\_PRO\\_060974.pdf](http://www.law.nyu.edu/sites/default/files/ECM_PRO_060974.pdf).
- 19 Keith N. Hylton, “An Economic Perspective on Preemption,” *Boston College Law Review*, Vol. 53 (2012), p. 210, [http://bclawreview.org/files/2012/10/05\\_hylton.pdf](http://bclawreview.org/files/2012/10/05_hylton.pdf).
- 20 For example, the partial deregulation of the U.S. aviation industry resulted in greater competition and efficiency in the airline industry, which in turn “democratized air travel, making it more accessible to the general public.” Fred Smith and Braden Cox, “Airline Deregulation,” in David Henderson (ed.), *The Concise Encyclopedia of Economics* (Indianapolis: Liberty Fund, 2007), <http://www.econlib.org/library/Enc/AirlineDeregulation.html>.
- 21 For a detailed discussion of how modern property and tort law could be applied to property interests in spectrum, see Ellen P. Goodman, “Spectrum Rights in the Telecom to Come,” *San Diego Law Review*, Vol. 41 (2004), p. 269, [https://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=484922](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=484922).
- 22 Ben Christopher, “The Spectrum Auction: How Economists Saved the Day,” *Priceonomics*, August 19, 2016, <https://priceonomics.com/the-spectrum-auction-how-economists-saved-the-day/>.
- 23 Federal Communications Commission, “Auctions Summary,” accessed February 2, 2017, [http://wireless.fcc.gov/auctions/default.htm?job=auctions\\_all](http://wireless.fcc.gov/auctions/default.htm?job=auctions_all).
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