The Economic Value of Property Rights Concepts in Spectrum, Both With and Without Licenses

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I. INTRODUCTION AND EXECUTIVE SUMMARY

Economists have long recognized the importance of concepts associated with property rights for the efficient operation of an economy. These concepts are important for all assets in an economy. Where economies flounder, economists often prescribe greater clarity of property rights. Where economies succeed, the result is attributable at least in part to clear property rights.[1]

Nobel Laureate Ronald Coase and others have examined in detail the importance of concepts related to property rights for licensed spectrum and the economic benefits from allowing greater property rights.[2] Over the past 55 years, substantial progress has been made in reinforcing property rights concepts in spectrum licenses including, as recommended by Professor Coase, the auctioning of rights to assignments of spectrum licenses when transferring spectrum from the public to the private sector.[3] Correspondingly, the value of applications in licensed spectrum has increased more rapidly than the economy as a whole.[4] This increase in value is, consistent with a Coasian view, attributable at least in part to the clear property rights in licensed spectrum.

[1] See Allan Meltzer, *Why Capitalism?* (Oxford University Press, 2012).
[2] Ronald H. Coase, *The Federal Communications Commission*, 2 THE JOURNAL OF LAW & ECONOMICS, 1–40 (1959), http://www.jstor.org/stable/724927. Ronald H. Coase, *The Problem of Social Cost*, 3 *The Journal of Law & Economics*, 1–44,http://www.jstor.org/stable/724810.
[3] In language predating Professor Coase's work, federal statute prohibits the private ownership of spectrum. 47 U.S.C. § 301. But federal statute, in language from 1993, requires the auctioning of licenses for mutually exclusive applications that are part of blocks of spectrum transferred from the federal government to the private sector. 47 U.S.C. § 309(j).
[4] See, e.g., Harold Furchtgott-Roth, *The Wireless Sector: A Key to Economic Growth in America*, report prepared for CTIA (2009).

If concepts of property rights in licensed spectrum contribute substantially to economic value of applications of that spectrum, it would stand to reason that spectrum with *lesser* or even no property rights would have applications with *lesser* economic value. A natural economic experiment follows: is licensed spectrum associated with higher economic value and higher valued applications than spectrum without licenses?

Licensed spectrum has enormous economic value in the United States. But, importantly, as we will see in this report, spectrum without licenses has large and rapidly growing value. In 1959 when Professor Coase wrote his initial article in this field, consumer electronic devices primarily focused on licensed spectrum. In 1960, there were 4,218 broadcast radio and television transmitters in the United States.[5] There were approximately 52 million television sets in the United States.[6] The same year, there were tens of millions of radio receivers. At the time, no one even kept track of unlicensed devices.

Today, the world is changed. The Consumer Electronics Association has estimated that there were approximately 3 billion unlicensed device sales in the United States in 2012 alone.[7] Billions more have been sold since. No doubt, there are many billion unlicensed devices today in the United States, including hundreds of millions with transmission capabilities. The total number of unlicensed wireless devices today is orders of

[5] U.S. Census Bureau, *Statistical Abstract of the United States*, *1970*, 495, Table 758, available at http://www2.census.gov/library/publications/1970/compendia/statab/91ed/1970-06.pdf.
[6] Glenn Elert, *Number of Television Sets in the United States* (Dec. 19, 2016, 3:25 PM), available at http://hypertextbook.com/facts/2007/TamaraTamazashvili.shtml.
[7] Consumer Electronics Association, *Unlicensed Spectrum and the American Economy* (2014), available at http://www.cta.tech/CorporateSite/media/gla/CEAUnlicensedSpectrumWhitePaper-FINAL-052814.pdf.

magnitude greater than the number of broadcast receivers in 1959, and higher than the number of all.

Today, countless billions of devices and countless applications use spectrum without licenses, including those that use specifically designated unlicensed spectrum bands, in the United States alone and around the world. Applications without licenses are ubiquitous. We American consumers depend on WiFi, Bluetooth, GPS receivers, and countless other unlicensed spectrum technologies unknown just a few years ago. We enjoy services that were once unimaginable at any price, and today we have them at little or no incremental cost. We cannot imagine life without unlicensed spectrum devices. Consider also:

- More than 10 billion radio frequency identification tags are estimated to be shipped in 2016 alone, most of which are unlicensed.[8]
- Many if not most consumer electronic devices today have Wi-Fi, Bluetooth, or some other wireless technology that uses un-licensed spectrum.
- Specifically designated unlicensed bands are some of the most intensively used spectrum bands today.
- According to Cisco, globally, "By 2015, more than half of all traffic from mobile-connected devices (almost 3.9 exabytes) will be offloaded to the fixed network by means of Wi-Fi devices and femtocells each month."[9]

[8] Raghu Das & Peter Harrop, RFID Forecasts, Players and Opportunities 2016-2026 (IDTechEx, 2016), available at http://www.idtechex.com/research/reports/rfid-forecasts-players-and-opportunities-2016-2026-000451.asp.

- Economic estimates of the value of spectrum not subject to license alone in the United States are in the many billions of dollars and almost certainly underestimate actual value substantially.[10] The value of all spectrum not subject to licensing is substantially greater.

These and other indicia reveal the rapidly growing economic importance in the United States and globally of spectrum not subject to licenses. The result, that the economic value of applications using spectrum not subject to licensing has grown even more rapidly, begs two questions:

1. Can applications and spectrum assets without licenses and without clear property rights have substantial economic value even without clear property rights?

2. Does spectrum without licenses actually have substantial property rights concepts?

This paper concludes that applications of spectrum not subject to licenses actually have various property right concepts, particularly rights to use and rights to benefit from use, that enhance their value. The paper reviews various concepts of property rights present in varying degrees in all forms of spectrum: (1) the rights to determine the use of spectrum,

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[9] Cisco, Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2015–2020 White Paper (2016), available at http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.html.

[10] See, e.g., Consumer Electronics Association, Unlicensed Spectrum and the American Economy: Quantifying the Market Size and Diversity of Unlicensed Devices (2014), https://www.cta.tech/cta/media/policyImages/policyPDFs/UnlicensedSpectrumWhitePaper.pdf; Raul Katz, Assessment of the Economic Value of Unlicensed Spectrum in the United States (2014),, available at http://www.wififorward.org/wp-content/uploads/2014/01/Value-of-Unlicensed-Spectrum-to-the-US-Economy-Full-Report.pdf.

(2) the rights to benefit from the use of spectrum, and (3) the right to benefit from transactions of spectrum.

To facilitate further and clearer property rights concepts in spectrum without licenses, I propose five simple steps:

- First, do no harm;
- Recognize all forms of spectrum as having at least some elements of property rights; [11]
- Simplify federal spectrum regulation;
- Rely even more on the Institute for Electrical and Electronics Engineers (IEEE) and other standards-settings bodies; and
- Develop expedited dispute resolution procedures.

The remainder of the paper is organized in the following sections:

2. Spectrum has become an increasingly important asset in the United States;
3. Spectrum is allocated in many different ways in the United States all of which make clarifying spectrum rights more important;
4. Clarifying property rights concepts is important for economic activity;
5. Spectrum usage decisions are made by zoning authorities, manufacturers, service providers, consumers, and enterprise customers;

[11] In a separate paper, I have argued for clearer property rights in licensed spectrum, a concept I call "Open Spectrum." H. Furchtgott-Roth, "Open Spectrum: A Major Step for U.S. Innovation and Economic Growth" (Hudson Institute, 2013) available at http://dev.hudson.org/content/researchattachments/attachment/1134/open_spectrum_final.pdf.

6. There is little difference between licensed and other spectrum in the property rights concept of choice of use;
7. There is little difference between licensed and other spectrum in the property rights concept of benefit from use;
8. Licensed spectrum has greater benefit from transactions than other forms of spectrum; and
9. For the reasons above, the value of applications for spectrum without license has grown rapidly and will likely continue to grow rapidly if policy recommendations are followed.

II. SPECTRUM HAS BECOME AN INCREASINGLY IMPORTANT ASSET IN THE UNITED STATES

Spectrum has become an increasingly valuable asset in the United States. With the increasing value has come increasing, often harmful and restrictive, regulation. Regulation of spectrum over the past 30 years, however, has moved towards greater flexibility of use and greater reliance on market forces and property concepts. Spectrum regulation has not always been benign. To help understand where spectrum regulation is today and where it might go in the future, this section reviews this evolution of spectrum regulation in the United States.

In the United States before 1906, all spectrum was unregulated.[12] Absence of regulation ended in 1906, followed by several milestones in the history of spectrum regulation in the United States:

- The early evolution of spectrum
- 1906 Berlin Conference
- 1912 Radio Act
- 1927 Radio Act
- 1934 Communications Act
- 1938 Part 15 Rules
- 1989 Part 15 Rules
- The development of mobile spectrum applications.

I will review each in turn.

A. The early evolution of spectrum

Spectrum itself is a curious word. In common parlance, it can mean a *range*, as in a "spectrum of ideas." Spectrum is the radio-magnetic frequency of energy that includes not only the cell phone, broadcast, and WiFi signals, but also frequencies that the FCC does not regulate, such as visible light. We also rely on other types of frequencies that we have chosen not to regulate through the FCC – sound, which is the oscillation of atmospheric pressure rather than electromagnetic field strength. If there is energy, there is spectrum.

[12] There are several histories of the early regulation of spectrum. One good source is Thomas H. White, "Early Government Regulation (1903-1941)," *United States Early Radio History*," available athttp://earlyradiohistory.us/sec023.htm.

Spectrum is not a new concept. It is timeless.

> And God said, Let there be light: and there was light.
> And God saw the light, that it was good: and God divided the light from the darkness.
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> *Bible, King James Version, Genesis*, I, 3-4.

The translators of the Bible in 1611 did not use the word "spectrum" for light because the word was just being introduced to the English language. At that time, it meant an apparition or specter, not light.[13] Scientific understandings of the origins of the universe are based in part on radiation spectrum.[14] Moreover, without spectrum, life could not exist. Our senses are informed by spectrum from the sounds we hear to the light we see to the warmth we feel. The history of human experience is in large part the story of the increasing control over and use of spectrum from grunts to the spoken word to music, from fire to electricity to nuclear energy, from invisible spectrum to cures for the common cold to cures for the most obscure forms of cancer. In countless other examples people have harnessed spectrum in ways unique to humanity.

The word "spectrum" gained popularity in reference to dividing light into bands from Sir Isaac Newton. He used the word more than 100 times to refer to the spectrum of light and color in his 1730 opus, *Opticks or, a Treatise of the Reflections, Refractions, Inflections, and Colours of Light,* as if the mere repetition of the word would reflect its importance.[15]

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[13] Spectrum, http://www.etymonline.com/index.php?term=spectrum.
[14] NASA,, available at http://science.nasa.gov/astrophysics/focus-areas/what-powered-the-big-bang/.
[15] See, Isaac Newton, *Opticks or, a Treatise of the Reflections, Refractions, Inflections, and Colours of Light*(printed for WILLIAM INNYS at the West-End of St. *Paul's*, London, 1730, 4th ed. 1730), available

By the 19th century, physicists such as Michael Faraday, James Maxell, and Heinrich Hertz developed our understanding of the electron magnetic spectrum and the relationship between spectrum and energy.[16] Various individuals applied the concepts of Hertz and Maxwell to develop what became wireless telegraphy.[17] But it was Guglielmo Marconi who used these developments in the understanding of the spectrum to obtain the first widely useful patent for wireless telegraphy and what is now known as the radio.[18] While he may not have single-handedly invented wireless telegraphy, he certainly helped commercialize it in the 1890s and 1900s. And Marconi's initial commercialization of wireless telegraphy was based on spectrum that at the time was without licenses.

B. 1906 Radiotelegraph Convention of Berlin

Until the latter half of the 19th century, the concept of spectrum was not widely known, and the division between licensed and unlicensed spectrum would have been meaningless. Marconi's wireless telegraphy was an extraordinary invention. Previously, electronic communication was limited to wires between fixed locations: a telegram from one town to another. Marconi's invention meant that communications could be sent between both fixed and mobile locations, such as ships at sea. Before Marconi's invention, a ship at sea would have no communication with the rest of the world for days or week on end. No longer.

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available at http://www.relativitycalculator.com/pdfs/Opticks_by_Sir_Isaac_Newton.pdf.
[16] See, e.g., I. Bernard Cohen, *Revolution in Science* (Harvard University Press, 1987).
[17] For a historical review, see Linwood S. Howeth, *History of Communications-Electronics in the United States Navy*, available at http://earlyradiohistory.us/1963hw02.htm.
[18] Nobelprize.org, available athttp://www.nobelprize.org/nobel_prizes/physics/laureates/1909/marconi-bio.html.

Marconi's invention was not costless. It required three elements: (1) costly equipment including wireless transmitter and receiver; (2) a trained radio operator; and (3) spectrum. Before 1906, none of these three was regulated. Equipment was scarce as were trained operators. To be of any practical value, wireless transmissions had to be sent on a frequency that wireless receivers could recognize and receive. For ships at sea from different nations, coordination of frequencies for wireless telegraphy seemed necessary. Thus was born the Berlin Conference in 1906. Although not ratified by the U.S. Senate until 1912, the 1906 Berlin Conference foreshadowed licensing and regulation of spectrum in the United States.

In 1906, barely a decade after the invention and commercialization of wireless telegraphy, several major nations, including the United States, met in Berlin to develop an international agreement on both wireless telegraphy and spectrum in what became known as the first International Radiotelegraph Convention or Conference.[19] The 1906 Berlin Conference built on the 1875 St. Petersburg International Telegraph Convention.[20] Although each country was allowed to enter separate statements to accompany each provision of the agreement and each provision of the attached regulations, the signatory countries appear to have agreed to at least a general framework for international wireless telegraphy. The 1906 conference agreed upon the designation of shipboard and coastal stations, the "exchange radiograms without distinction of the radio system adopted by

[19] ITU, available at http://handle.itu.int/11.1004/020.1000/4.36.
[20] See Article 17 of the 1906 Berlin Convention.

such stations,"[21] international rates for wireless telegraphs, and a set of regulations.[22] The Berlin Conference also adopted regulations including the two frequencies of ship-to-shore and shore-to-ship wireless telegraphy, distress signals, and wavelengths for the operation of wireless telegraphy.

The 1906 Berlin Conference did not rely on private entities to resolve disputes. Instead, it focused on reinforcing government authority to regulate spectrum. With a meeting of government officials in Berlin, the conference decided unsurprisingly that government officials would be best at resolving disputes between conflicting uses of spectrum. Much of the Conference's concerns were over interference.

1. Concern over interference

Although wireless telegraphy was just a new technology, the record of the Berlin Conference lists 25 different references to concerns over interference between wireless users. The Conference was concerned not merely with coordination to assure that transmitted signals were received, but the Conference was also concerned that simultaneous signals from different wireless telegraphy transmitters on the same wave length would conflict and interfere with one another.

Further, the Conference also expressed concern about interference between entirely different services using the same wavelength. For example, France objected to just two

[21] *Id.* Article 3.
[22] *Id.* Article 11.

wavelengths, 300 meters and 600 in Article II, described above. France saw interference from different services.[23]

2. Regulation of wave lengths

The conference adopted regulations setting standard wave lengths for communications at 300 meters and 600 meters.[24] The wave lengths can be converted directly in the currently used megahertz (MHz). Thus, 300-meter wave lengths correspond to 1 MHz; 600-meter wave length corresponds to 500 Kilohertz.[25] A 1600-meter wave length corresponds to 187.4 kHz. Effectively, the Berlin Conference adopted 500 kHz and 1 MHz as the standard frequencies for wireless telegraph messages for "general public use." Each coastal station "shall use one or the other of these two wave lengths." Governments might authorize "the employment of other wave lengths designed to insure long-range

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[23] *Id.* Proposition of France. "It seems necessary to fix a maximum wave length for radiophares (radio stations for aids to navigation) in order to avoid the disturbances which these stations might introduce into the working of other stations. A maximum wave length of 100 meters would be sufficient. In the same manner it would be of advantage to provide a wave length to be employed by coastal stations sending time signals or transmitting meteorological telegrams. This measure would facilitate the reception of such signals and correspondence by the stations on shipboard. This wave length might be fixed at 2,500 meters."

[24] *Id.,* Service Regulation 1.2. "Two wave lengths, one of 300 meters and the other of 600 meters, are authorized for general public service. Every coastal station opened to such service shall use one or the other of these two wave lengths. During the whole time that a station is open to service it shall be in condition to receive calls according to its wave length, and no other wave length shall be used by it for the service of general public correspondence. Each Government, may, however, authorize in coastal stations the employment of other wave lengths designed to insure long-range service or any service other than for general public correspondence established in conformity with the provisions of the Convention, provided such wave lengths do not exceed 600 meters or that they do exceed 1,600 meters.[24]

> 1. The normal wave length for stations on shipboard shall be 300 meters. Every station on shipboard shall be installed in such manner as to be able to use this wave length. Other wave lengths may be employed by such stations provided they do not exceed 600 meters.
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> 2. Vessels of small tonnage which are unable to have plants on board insuring a wave length of 300 meters may be authorized to use a shorter wave length."

[25] To translate from meters to MHz, see http://www.translatorscafe.com/cafe/EN/units-converter/frequency-wavelength/27-6/wavelength_in_metres-megahertz/.

service or any service other than for general public correspondence" but such frequencies must have been greater than 500 kHz or less than 187.4 kHz.

3. Regulation of stations

The Berlin Conference also adopted identification and regulation of each radio station, both coastal and shipboard. The registration of radio stations was to be coordinated by an "International Bureau" of the International Telegraph Union, the precursor of today's ITU. At the time, radio stations were costly and rare, and required registration with the International Bureau. [26]

4. Government license and certification of shipboard stations and shipboard radio operators

The Berlin Conference also adopted regulations that mandated that all shipboard radio stations and radio operators be subject to government license and certification.[27] In 1910,

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[26] *Id*., Service Regulation 1.4. "The International Bureau shall be charged with drawing up a list of radio stations of the class referred to in article 1 of the Convention. Such list shall contain for each station the following data:

(1) Name, nationality, and geographical location in the case of coastal stations; name, nationality, distinguishing signal of the International Code, and name of ship's home port in the case of stations on shipboard.

(2) Call letters (the calls shall be distinguishable from one another, and each must be formed of a group of three letters). …

(6) Wave lengths used by the station (the normal wave length to be underscored). …"

[27] *Id.*, Service Regulation 1.6. "No station on shipboard shall be established or worked by private enterprise without authority from the Government to which the vessel is subject. Such authority shall be in the nature of a license issued by said Government.

2. Every station on shipboard that has been so authorized shall comply with the following requirements:

(a) The system employed shall be a syntonized system.

Congress passed "An Act to require apparatus and operators for radio communication on certain ocean steamers."[28]

The 1906 Berlin Conference and the 1910 Radio Act did not formally regulate or license spectrum, but they presaged the end of completely unregulated spectrum. The Radio Act of 1912 marked the beginning of licensed spectrum.

C. The Radio Act of 1912

Until 1912, most federal activity regarding radio was limited to wireless telegraphy, and primarily international and naval aspects of wireless telegraphy. Both amateur and commercial radio operations developed outside of these realms. The United States Congress passed the Radio Act of 1912, the first American law requiring licenses of all

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(b) The rate of transmission and reception, under nor- mal conditions, shall not be less than 12 words a minute, words to be counted at the rate of 5 letters each.

(c) The power transmitted to the radio apparatus shall not, under normal conditions, exceed 1 kilowatt. Power exceeding. 1 kilowatt may be employed when the vessel finds it necessary to correspond while more than 300 kilometers (161.88 nautical miles) distant from the nearest coastal station, or when, owing to obstructions, communication can be established only by means of an increase of power.

3. The service of the station on shipboard shall be carried on by a radio operator holding a certificate issued by the Government to which the vessel is subject. Such certificate shall attest the professional efficiency of the operator as regards—

(a) Adjustment of the apparatus.

(b) Transmission and acoustic reception at the rate of not less than 20 words a minute.

(c) Knowledge of the regulations governing the exchange of radio correspondence.
4. The certificate shall furthermore state that the Government has bound the operator to secrecy with regard to the correspondence. the operator to secrecy with regard to the correspondence."

[28] See http://earlyradiohistory.us/1910act.htm. "[I]t shall be unlawful for any ocean-going steamer of the United States, or of any foreign country, carrying passengers and carrying fifty or more persons, including passengers or crew, to leave or attempt to leave any port of the United States unless such steamer shall be equipped with an efficient apparatus for radio-communication, in good working order, in charge of a person skilled in the use of such apparatus, which apparatus shall be capable of transmitting and receiving messages over a distance of at least one hundred miles, night or day."

radio stations.[29] The Radio Act not only required that radio stations be licensed, but specified that the licenses would designate spectrum, or wavelengths, in which the radio station could operate.[30]

The Department of Commerce then promulgated rules in 1913 to implement the Radio Act.[31] These rules made specific reference to the Berlin Conference and established regulated radio wave lengths as "wave length shall not exceed six hundred meters or it shall exceed one thousand six hundred meters."[32] Thus, after the rules were promulgated, the Department of Commerce determined that regulated radio stations should operate at frequencies between 500 KHz and 187.4 KHz.

When the Radio Act of 1912 was passed, the primary use of radio was for wireless telegraphy. In subsequent years, radio broadcasting became popular, with radio stations licensed by the Department of Commerce. In 1922 and in subsequent years, Secretary

[29] Radio Act of 1912, Pub. L. No. 264, available at http://earlyradiohistory.us/1912act.htm. "That a person, company, or corporation within the jurisdiction of the United States shall not use or operate any apparatus for radio communication as a means of commercial intercourse among the several States… or where interference would be caused thereby with the receipt of messages or signals from beyond the jurisdiction of the said State or Territory, except under and in accordance with a license, revocable for cause, in that behalf granted by the Secretary of Commerce and Labor upon application therefor;".

[30] *Id.*, "That every such license shall be in such form as the Secretary of Commerce and Labor shall determine and . . . shall state the wave length or the wave lengths authorized for use by the station for the prevention of interference and the hours for which the station is licensed for work; and shall not be construed to authorize the use of any apparatus for radio communication in any other station than that specified. Every such license shall be subject to the regulations contained herein, and such regulations as may be established from time to time by authority of this Act or subsequent Acts and treaties of the United States."

[31] The Department of Commerce and Labor was renamed the Department of Commerce in 1913. See also http://earlyradiohistory.us/1912act.htm.

[32] Radio Act of 1912, Pub. L. No. 264, available at http://earlyradiohistory.us/1912act.htm.

Herbert Hoover issued the National Radio Conference Report.[33] Although, there is no discussion specifically of spectrum without licenses in any of these annual reports, they have several striking features with respect to unlicensed spectrum:

- The 1922 Report included a chart with spectrum allocation between 50 Khz and 3 Ghz.[34] Each of the reports had a spectrum chart, but spectrum above 3 Ghz was simply listed as "reserved." Presumably, the spectrum above 3 GHz could have been considered, in some sense, spectrum without licenses.
- Most bands of spectrum were assigned to a unique service; there was no sharing and few overlapping allocations, and no overlapping federal and non-federal allocations.
- Many of the spectrum bands were "nonexclusive," presumably meaning regulated but not requiring a license.

In the 1920s, the licensed radio broadcast industry flourished. The 1924 Radio Conference Report stated:

> At the end of four years 530 are in operation, making radio available to every home in the country. The sales of radio apparatus have increased from a million dollars a year to a million dollars a day. It is estimated that over 200,000 men are now employed in the industry, and the radio audience probably exceeds 20,000,000 people.[35]

The National Radio Conference Reports generally described positively the health of the industry. There is no general sense in the reports of a lack of regulatory authority, and

[33] See, e.g., Report of the Department of Commerce Conference on Radio Telephony (1922), available at http://earlyradiohistory.us/1922conf.htm.
[34] *Id.*.
[35] Recommendations for Regulation of Radio Adopted by the Third National Radio Conference (1924), available at http://earlyradiohistory.us/1924conf.htm.

there is no discussion of unlicensed spectrum. As Professor Thomas Hazlett has documented, the radio industry expanded continuously through the 1920s.[36] Professor Hazlett describes the "priority-in-use" form of property rights implicit in the licensing for broadcast radio spectrum that protected incumbent broadcasters from 1920-1926 at the expense of new entrants.[37] The priority-in-use property rights were defensible in court.[38]

In 1925, the Department of Commerce challenged in court the Zenith Radio Corporation for violating federal radio rules on power emissions and frequency allocation promulgated under the 1912 Radio Act.[39] The court in 1926 found that the Department of Commerce did not have specific authority to promulgate such rules.[40]

The development of the broadcast radio industry in the 1920 has been widely and inaccurately criticized as unregulated, unlicensed, and chaotic. In subsequent decades, the Radio Act of 1927 has taken on an aura of a law designed to replace chaos in spectrum management. In *Red Lion v. FCC*, the court went to lengths to recount, erroneously, the history of the Radio Act of 1927.[41] Justice White delivered the opinion of the Court:

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[36] Thomas W. Hazlett, "The Political Spectrum: From Marconi to the iPhone, the Quest to Liberate Wireless Technologies of Freedom," Presentation at the Center for the Economics of the Internet, Hudson Institute (Dec. 9, 2015), available at https://s3.amazonaws.com/media.hudson.org/files/publications/20151209Hazlett.pdf.
[37] Thomas W. Hazlett, Optimal Abolition of FCC Spectrum Allocation, 22 Journal of Economic Perspectives 103-128 (2008), available at http://pubs.aeaweb.org/doi/pdfplus/10.1257/jep.22.1.103.
[38] Thomas W. Hazlett, "The Political Spectrum: From Marconi to the iPhone, the Quest to Liberate Wireless Technologies of Freedom," Presentation at the Center for the Economics of the Internet, Hudson Institute (Dec. 9, 2015), available at https://s3.amazonaws.com/media.hudson.org/files/publications/20151209Hazlett.pdf.
[39] United States v. Zenith Radio Corporation et al, D. District Court N. D. Illinois (D. April 16, 1926), available at https://apps.fcc.gov/edocs_public/attachmatch/DOC-328551A1.pdf
[40] *Id.* "There is no express grant of power in the act to the Secretary of Commerce to establish regulations."
[41] Red Lion Broadcasting Co., Inc. v. FCC, 395 U.S. 367 (1969).

> Before 1927, the allocation of frequencies was left entirely to the private sector, and the result was chaos. It quickly became apparent that broadcast frequencies constituted a scarce resource whose use could be regulated and rationalized only by the Government. Without government control, the medium would be of little use because of the cacaphony [sic] of competing voices, none of which could be clearly and predictably heard. Consequently, the Federal Radio Commission was established to allocate frequencies among competing applicants in a manner responsive to the public "convenience, interest, or necessity." [42] [footnotes omitted]

Of course, none of the revisionist history was remotely accurate. Before 1927, broadcast stations were licensed and regulated by the Department of Commerce. As the industry prospered, there was no "cacaphony [sic] of competing voices, none of which could be clearly and predictably heard."

D. The Radio Act of 1927

Less than a year after the court decision in *Zenith Radio*, Congress passed the Radio Act of 1927.[43] Where the Court had said that the 1912 Radio Act offered the Department of Commerce and the federal government no specific authority to regulate, the 1927 Radio Act left no ambiguity: the purpose of the Act was to regulate radio communications in all manner and all forms.[44] The 1927 Radio Act had several salient features including:

- Except for intrastate communications, "all forms of interstate and foreign radio transmissions and communications" were to be regulated. The concept of distinct

[42] *Id.*
[43] Radio Act of 1927, Pub. L. No. 632, available at http://earlyradiohistory.us/1927act.htm.
[44] *Id.* "That this Act is intended to regulate all forms of interstate and foreign radio transmissions and communications within the United States, its Territories and possessions; to maintain the control of the United States over all the channels of interstate and foreign radio transmission;
and to provide for the use of such channels, but not the ownership thereof, by individuals, firms, or corporations, for limited periods of time, under licenses granted by Federal authority, and no such license shall be construed to create any right, beyond the terms, conditions, and periods of the license. That no person, firm, company, or corporation shall use or operate any apparatus for the transmission of energy or communications or signals by radio . . . "

intrastate wireless radio communication eventually disappeared to be replaced by complete federal regulation of all radio communication.

- A "public interest" standard was imported from the Interstate Commerce Act;
- It sought to "maintain control of the United States over all the channels of interstate and foreign radio transmission" through licenses. This concept of "control" was not present in the 1912 Act.
- It forbade "the ownership [of spectrum], by individuals, firms, or corporations, for limited periods of time, under licenses granted by Federal authority, and no such license shall be construed to create any right, beyond the terms, conditions, and periods of the license." Previously, under the 1912 Act, spectrum ownership was not specifically addressed. The 1927 Act did not address ownership of unlicensed spectrum. In assigning radio licenses, the Radio Commission required licensees to disavow any ownership interest in spectrum.
- It created an independent commission, the Radio Commission.

Quite likely, the 1927 Radio Act was the high point in federal zeal to control all spectrum through licenses. There were no exceptions for unlicensed spectrum or unregulated spectrum.

E. Communications Act of 1934

The Communications Act of 1934 was New Deal legislation that combined the telephone regulation of the Interstate Commerce Commission with the radio regulation of the Radio

Commission in a new independent agency, the Federal Communications Commission.[45] The language of the Radio Act of 1927 was largely imported as Title III of the Communications Act. The word "unlicensed" does not appear in the original 1934 Act, nor was there any discussion of spectrum without licenses.

F. 1938 – 1989

In 1938, the FCC adopted rules specifically for unlicensed devices to be operated without license under Part 15.[46] This was a major concession on the part of the FCC as it could have taken the position that no unlicensed devices or spectrum were permitted under statute. Indeed, neither the concept nor the words of unlicensed spectrum are in the 1934 Act. Today, a few isolated phrases can be found in a few sections such as 332, but the manner of addressing unlicensed spectrum and unlicensed devices is not explicitly mentioned in the statute.

The FCC recognized that, even with 1930s technology, having the Commission license every use and every device was an unmanageable task. The FCC's approach in 1938 was that permitted devices had relatively low levels of RF as long as the operation caused no harmful interference to licensed services and the device did not generate emissions or field strength levels greater than a specified level. In 1938, most unlicensed devices operated in the MF band (0.3 – 3 MHz) or the HF band (3 – 30 MHz).[47] Over time, more manufacturers sought permission for unlicensed devices in higher frequency bands, but

[45] Communications Act of 1934, Pub. L. No. 416. "An Act To provide for the regulation of interstate and foreign communication by wire or radio, and for other purposes."
[46] 4 FCC Rcd. 3494, available at http://digital.library.unt.edu/ark:/67531/metadc1680/m1/138/?q=4. See 4 FCC Rcd. 3493-3556.
[47] See 4 FCC Rcd. 3493-3556.

meeting the field strength limits was difficult as those limits decreased with increasing frequency.[48] Over time, the FCC amended Part 15 rules to allow for specific unlicensed devices whose mass marketing could be demonstrated not to cause harmful interference to authorized radio services.[49] The procedural result was a product-by-product review for the FCC to create exceptions. From the 1960s through the 1980s, the FCC created specific exceptions for devices such as wireless microphones, telemetry devices, garage door openers, baby monitors, VCRs, auditory assistance devices, cordless telephones, and alarm systems.[50]

By the 1980s, Part 15 had become a "Mother-May-I?" game at the FCC. New authorizations were granted, sometimes after years, in response to petitions for rulemaking for specific devices only.[51] It was an incremental approach, device by device. The result was a complex set of rules specific for each type of device, inconsistent with similar devices receiving different interference standards.[52] Businesses that knew how to frame their requests best were more likely to gain approval than those that did not. But always, the FCC was in the middle with the discretion to say "no", the discretion to delay and the discretion to say yes under certain conditions.

Between 1938 and 1989, therefore, the permissible uses of unlicensed spectrum were ill-defined. Individuals and businesses could use unlicensed spectrum only in ways that

[48] *Id.*
[49] *Id.*
[50] *Id.*
[51] *Id.*
[52] *Id.*

were approved in advance by the FCC. The individual, like the manufacturer, was a participant in a game of "Mother May I?"

But, even so, there were limited property rights concepts at least for equipment, if not for the unlicensed spectrum itself. An individual could decide whether or not to use an FCC approved baby monitor, or a garage door opener, or a VCR--or other devices that had been approved by the FCC under Part 15--in the comfort of home. Individual businesses could and did monetize FCC-approved Part 15 devices.

G. Part 15 Rules: 1989 – present

In 1987, the FCC opened a proceeding to update its 50-year old rules and streamline the Part 15 device rules for unlicensed spectrum.[53] Two years later in 1989, the FCC adopted an order that simplified Part 15 rules.[54] Although the specific rules have been amended from time to time over the past 27 years, the structure of the Part 15 rules is the same today as adopted in 1989. The Part 15 rules do not mention the word "property." By 2015, there were more than 100 pages of Part 15 rules in the Code of Federal Regulations, with tailored rules for specific bands of spectrum and specific applications.[55] While core rules are relatively simple, efforts to share spectrum with government uses have added complexity in particular bands, such as the U-NII-2 band. Even with complexities in particular frequency ranges, the 1989 Part 15 rules were a vast improvement on the rules that preceded them.

[53] *Revision of Part 15 of the rules regarding the operation of radio frequency devices without an individual license*, Notice of Proposed Rulemaking, 2 FCC Rcd. 6135 (1987).
[54] *Revision of Part 15 of the rules regarding the operation of radio frequency devices without an individual license*, First Report and Order, 4 FCC Rcd 3493 (1989).
[55] 47 C.F.R.§ 0-19 (2015).

In fact, it is difficult to overstate the importance of the 1989 rules to the current structure of Part 15 devices. The new rules allowed for effectively an unlimited range of applications without prior approval by the FCC as long as certain conditions—accepting interference and power limits—were met. The vast array of Part 15 device and spectrum applications that have developed since 1989 was at least partly made possible by the new Part 15 rules. If the FCC had not changed the rules, all new applications would likely still be subject to individual, time-consuming, and arbitrary review proceedings at the FCC. The American consumer—and, indeed consumers around the world as other countries largely follow our Part 15 rules—has enormously benefited.

The development of mobile wireless services

Beginning in the 1980s, mobile wireless communications services began to grow rapidly in the United States and around the world.[56] Mobile communications services not only created enormous value to consumers and businesses around the world, but they also substantially increased the value of spectrum generally, both licensed and not. More valuable spectrum increased the importance of efficient allocation of spectrum, which in turn helped lead to adoption of such regulatory innovations as auctions for the transfer of spectrum from the government to the private sector and improved secondary markets for spectrum licenses, and increased access to unlicensed spectrum.[57] New mobile

[56] For their economic growth, see, e.g., H. Furchtgott-Roth, *The Wireless Sector: A Key to Economic Growth in America*, report prepared for CTIA (2009).
[57] See 47 U.S.C. § 309(j).

technologies such as 5G will often employ combinations of both licensed and unlicensed spectrum.

For the past thirty years, more flexible spectrum regulation, which can be associated with greater property rights in spectrum, has coincided with greater value in spectrum, both licensed and not licensed.

III. SPECTRUM IS ALLOCATED IN MANY DIFFERENT WAYS IN THE UNITED STATES ALL OF WHICH MAKE CLARIFYING SPECTRUM RIGHTS MORE IMPORTANT

Beginning in the late 19th and early 20th centuries, national governments around the world began regulating spectrum roughly within the limits of contemporaneous technology. In the United States, the allocations were initially between spectrum reserved for the federal government and spectrum not reserved for the federal government. Spectrum reserved for the federal government was allocated among various federal agencies for specific purposes and managed by the National Telecommunications and Information Administration (NTIA). The spectrum not reserved for the federal government was allocated over time for a variety of different purposes, with some spectrum having license assignments to specific entities, and some spectrum not having such a licensing structure. Non-federal spectrum allocations are managed by the FCC. Today, practically all bands of spectrum in the United States are allocated for more than one purpose with many different applications in the same band.

A. Ways of partitioning spectrum regulation into different categories

In both FCC and NTIA spectrum allocation documents, it is clear that many different types of users occupy practically every band of spectrum. In addition to the formal allocations of spectrum, low-power users of spectrum may, subject to FCC Part 15 regulations, use almost any band of spectrum without license. Spectrum allocations and regulations in the United States are extraordinarily complex. We can examine this complexity in three dimensions:

1. The partition between spectrum subject to federal regulation and spectrum not subject to such regulation

The first partition is between spectrum subject to federal regulation and other spectrum.

a. Spectrum directly subject to federal regulation

The federal government currently regulates spectrum between 9 kHz and 275 GHz. The various purposes, regulations, allocations, and assignments of spectrum are recorded by the federal government. The FCC maintains a "Frequency Table of Allocations" recording the permissible uses of spectrum in each band.[58] The NTIA maintains a multi-colored "Frequency Allocation Chart" illustrating the various allocations of spectrum.[59] The chart has a rainbow of colors for different types of allocations.

[58] See 47 C.F.R. § 2.106 (2016).
[59] See https://www.ntia.doc.gov/files/ntia/publications/january_2016_spectrum_wall_chart.pdf.

b. Spectrum not directly subject to federal regulation

Use of some bands of unregulated spectrum, such as much of spectrum above 275 GHz and below 9 kHz, has never been subject to laws or regulation.[60] Even today, these bands are indirectly regulated even if, for example, a transmitter in these bands causes harmful interference to a licensed user in another band.

By spectrum not directly subject to federal regulation, I mean spectrum in bands that have never been regulated. Before 1906, regulation of spectrum was not contemplated. Even today, in the Code of Federal Regulation the Federal Communications Commission (FCC) regulates spectrum frequencies only between 9 kHz 275 GHz.[61] The regulated portion is only a part of the totality of electromagnetic spectrum. The regulated portion does not include, for example, visible light in higher frequencies.[62] As with all spectrum, these frequencies can be translated into energy and wavelengths.[63] As a function of technology and the limitations of legislators to imagine higher frequencies, these spectrum bands remain the unregulated spectrum frontier. As laws and technology change, these bands may one day be regulated.

[60] If use of any spectrum band were to interfere in a harmful manner with another band, that use would be subject to regulation.
[61] 47 C.F.R. § 2.106.
[62] Audible sound is between 20Hz and 20 kHz. See http://hyperphysics.phy-astr.gsu.edu/hbase/sound/earsens.html
[63] See, e.g., https://www2.chemistry.msu.edu/faculty/reusch/virttxtjml/cnvcalc.htm.

2. The partition between federal and non-federal users

Since at least 1906, the federal government has been keenly interested in spectrum for its own purposes, often military. Spectrum frequencies between 9 kHz – 275 GHz are divided between federal users (allocated through the NTIA) and non-Federal users, allocated through the FCC. Both the FCC and the NTIA have detailed and complicated rules for those users of spectrum that they allocate. Although the two agencies coordinate with one another, there remain two different sets of rules, for two different sets of users, all occupying and seeking to use the same spectrum. Federal uses of spectrum may also not be publicly disclosed for national security reasons, making it nearly impossible to identify conclusively the true users of a particular band.

Within the same band of spectrum, more than one spectrum application may be—and usually is—allocated on the federal side, and more than one spectrum application usually is allocated on the non-federal side. These competing uses may conflict with one another between the NTIA and FCC assignees. Or the uses may conflict with other uses in the same agency.

3. The partition between licensed spectrum uses and other uses

Even in the regulated portion of the spectrum (9 kHz – 275 GHz), some bands are subject to license while other bands are not subject to license. The FCC permits sharing in most of the regulated bands of spectrum at low energy levels through Part 15 unlicensed devices.

a. Allocations not subject to license

Some spectrum allocations are not subject to license, such as industrial, scientific and medical (ISM),[64] nautical communications within the United States,[65] and citizens band radio service.[66] These and other services are regulated with specific rules in the CFR that limit the use of the band to certain applications, but individual users of these bands are not required to obtain a separate license to operate, so long as they comply with any other applicable regulations. ISM spectrum is used for service ranging from microwave ovens to medical devices. Many of these applications are often used within private physical property. Intelligent transportation systems, particularly for automobiles, represent an example of spectrum allocated without licenses. [67]

b. Part 15 devices

Spectrum not subject to licenses also includes, and is most often associated with, spectrum applications in bands that are often subject to license but which have been exempted from license requirements. In the United States under FCC regulation, this spectrum is regulated under Part 15 and populated with Part 15 devices.[68] In practically all bands, applications without licenses are permitted under Part 15, although in most of these bands the FCC limits Part 15 operations to low power levels.[69]Although some Part 15 devices such as Wireless Internet Service Provider (WISP) transceivers can cover

[64] See 47 C.F.R. 18.
[65] See U.S. Coast Guard, Navigation Center, http://www.navcen.uscg.gov/?pageName=mtBoater.
[66] See FCC "Citizens Band Service" at https://www.fcc.gov/general/citizens-band-cb-service.

[68] 47 C.F.R. § 15. Curiously, the 1989 order on Part 15 devices prohibited unlicensed devices in certain bands. See 47 C.F.R. § 15.205.
[69] See 47 C.F.R. § 15.205 for the bands where unlicensed devices are prohibited. Even these likely allow unlicensed devices for ultra-wideband and other applications.

large areas, most Part 15 devices typically are short-range devices with substantial limits on power emissions. Part 15 devices usually must accept interference from other devices.

At the FCC on the non-federal side, in certain bands spectrum is allocated for a specific use with specific licensing requirements (e.g., broadcasting and Commercial Mobile Radio Service (CMRS)). In other bands, spectrum may be used without a license. These applications include allocations for a specific use without any licensing requirements for users such as maritime radio within the United States[70] and citizens band radio.[71]

4. Spectrum regulation outside the FCC and NTIA

Some bands of spectrum not regulated by the FCC or NTIA, such as visible light,[72] have long been subject to various non-federal laws including common law. Some forms of spectrum, such as X-rays,[73] ultraviolet light,[74] and infrared light, have in the past century been regulated by federal health and safety laws.[75] As the word *spectrum* was not introduced to the English language in its current scientific and engineering usage until the 19th century, it is not surprising that laws did not refer to spectrum in 19th century or earlier.

[70] See http://www.boatsafe.com/nauticalknowhow/radio.htm.
[71] See https://www.fcc.gov/general/citizens-band-cb-service.
[72] 400 – 800 THz. See David Terr, "The Electromagnetic Spectrum," available at http://www.davidterr.com/science-articles/electromagnetic_spectrum.html.
[73] 30 PHz to 30 EHz. *Id.*
[74] 800 THz to 30 PHz. *Id.*
[75] 300 GHz to 400 THz. *Id.*

Common law has long addressed issues of light, sound, and other forms of unregulated spectrum. In each instance, disputing parties used legal remedies other than appealing to the FCC, and these legal remedies were available.

Disputes surrounding conflicting uses of spectrum (RF and audible) are not new. From the biblical story of the Tower of Babel to modern times of building shadows in urban areas, spectrum, often without license, has been at the center of legal disputes. These disputes often center not on the *absence* of property rights, but rather on the *conflicting claims* on those property rights. Laws regarding interference and harmful interference related to spectrum, whether through nuisance or trespass, became more common in the 20th century.

Some common law concepts of spectrum associated with real property pertain to audible sound and visible light. Not surprisingly, many common law concepts and remedies for disputes involving property—trespass, nuisance, easement, and eminent domain—often involve at least some elements of spectrum. Under nuisance laws, one can lodge a complaint against an overly noisy neighbor. To preserve access to visible light, some property owners have easements limiting the height and type of building that can be erected on a neighboring plot of land. To create more visible light in a neighborhood, a municipality may use eminent domain to acquire property to build an urban park.

Unregulated use of spectrum is not limited to property owners on their property. Thus, individuals are generally free to use audible sound and visible light, both actively and

passively, whether they are on their own property or not. Partly, this outcome may reflect the partial public good nature of these spectrum bands; the cost of excluding individuals from the use of sound or light is usually prohibitively high. But even aside from the technological costs of restricting sound and light, human sensibilities and democratic principles tend towards not regulating sound and light. Without reference to property ownership, the First Amendment restricts laws that limit speech, which in its original and narrowest context would be audible sound. Similarly, again without reference to property, freedom of the press or written words can be viewed as freedom of visible light.

B. Spectrum not subject to licensing

Without license: the very words conjure lawlessness. A profession or an activity can be debased by the phrase "without license," such as driving "without a license." Even worse is the adjective "unlicensed" such as an unlicensed doctor or an unlicensed practitioner. In the normal use of the English language, that which could be licensed often ought to be licensed.

Of course, absence of a license has occasional advantages. In Britain, an "Off license" is retail outlet selling, among other goods, alcohol. There is at least one other notable exception where lack of license has substantial value: spectrum not subject to licensing.

What is "spectrum not subject to licensing?" Most spectrum experts might answer the question by rattling of a list of bands of spectrum that contain many unlicensed devices.[76]

[76] These bands include 900 Mhz, 2.4 Ghz, and 5 GHz.

But spectrum not subject to licensing is not limited to one or a handful of bands. By "spectrum not subject to licensing," I mean spectrum not assigned to a specific individual or entity by a specific government permission or license for use.

C. Growth in demand for spectrum and devices

As discussed in Section I, demand for all forms of devices using spectrum, both those using licensed spectrum and those not, including Part 15 devices, has exploded over the past two decades and is forecasted to continue to grow.[77] The United States tends to be the international leader in the use of spectrum, particularly unlicensed spectrum, with other countries following America's lead.

Growth in demand for spectrum and related devices not requiring licenses has not necessarily come at the expense of demand for licensed spectrum and devices. Many if not most devices for licensed spectrum—such as cell phones and television sets—have many embedded devices for unlicensed applications such as WiFi and Bluetooth. Unlicensed spectrum is increasingly used to offload traffic from licensed networks. Practically all cell phones, tablets, and computers now look for WiFi before looking for licensed spectrum. The new generation of mobile wireless technology, 5G, will likely make use of a combination of licensed and unlicensed spectrum.[78] The NTIA Spectrum

[77] For the increase in demand for licensed spectrum, see, e.g., Coleman Bazelon and Giulia McHenry, "Substantial Licensed Spectrum Deficit (2015-2019): Updating the FCC's Mobile Data Demand Projections," prepared for CTIA (2015), available at http://www.ctia.org/docs/default-source/default-document-library/brattle_350MHz_licensed_spectrum.pdf. For the increase in demand for spectrum not subject to licenses, see Cisco, "Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2015–2020 White Paper" (2016),, available at http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.html.

[78] See, e.g., *Establishing a More Flexible Framework to Facilitate Satellite Operations in the 27.5-28.35 GHz and 37.5-40 GHz Bands,* Notice of Proposed Rule Making, IB Docket No. 15-256 (2015).

Advisory Committee has for years worked on approaches to "sharing" between licensees and unlicensed users in certain spectrum bands.[79]

Devices using spectrum requiring licenses and devices using spectrum not requiring licenses are likely economic complements. As prices for unlicensed devices decreases, demand for licensed devices increases, and vice versa. Innovation in one leads to innovation in the other. It is difficult to find devices that use licensed spectrum only without also some use of unlicensed spectrum, although the reverse is not generally true.

Despite requiring FCC lab certification and despite often requiring IEEE coordination, unlicensed devices are readily available. The American specifications for equipment are widely accepted around the world. The exact magnitude of the contribution of unlicensed spectrum to the American economy is difficult to quantify but it is substantial. Life depends on visible light, and much of our economy depends on various forms of spectrum, including much that is not subject to license.

IV. CLARIFYING PROPERTY RIGHTS CONCEPTS IS IMPORTANT FOR ECONOMIC ACTIVITY

Before examining the application of property rights to spectrum not subject to licensing, it is well to understand the *economic* concept of property rights. I begin by reviewing how eminent thinkers have thought about property rights and the importance of property rights to economic activity and growth. Next, I explain how few if any goods and

[79] See NTIA, "CSMAC," available at https://www.ntia.doc.gov/category/csmac.

services are pure forms of property right. Indeed, assets from land to spectrum more often have only some characteristics of property rights. I then consider the role of government in clarifying property rights. I conclude with the concept of the incompleteness of property rights.

A. Economic thought on property rights

The concepts of property, ownership, control, and possession are as ancient as humanity and language. Most spoken languages either have possessive forms or can be constructed to indicate possession. The Soviet Union rid Russia of most forms of private property, but it could not rid the Russian language of the possessive form. Human ideas, thoughts, and words persist where governments and legal instruments may fail. Many great thinkers have written about property rights and their importance for both economic growth and social well-being. As Robert Frost noted: "Good fences make good neighbours."[80] Below, I review a few concepts from John Locke, Ronald Coase, Paul Samuelson, C.G. Hardin, and Armen Alchien.

1. John Locke

John Locke maintained that property was a natural right, the source of government and a concept that preceded government. According to Locke, private property predated government, and God had not bestowed upon a King or any government all of property. As a consequence, Locke held that "Government has no other end but the

[80] Robert Frost, "Mending Wall," https://www.poetryfoundation.org/poems-and-poets/poems/detail/44266.

preservation of property."[81] By that, Locke meant *private* property, property of individuals, not property of the government. It is impossible to know exactly how Locke would have approached property rights in spectrum generally or spectrum not subject to license in particular, but it is doubtful that he would have assumed either the sole province of the government.

Whether property is the cause or the effect of government, economists since Adam Smith have held that the *distribution* of property is more efficient when left to individual buyers and sellers rather than the intermediation of the government.[82] While earlier economists touched on some of the characteristics of property rights, in the mid-20th century economists focused their attention on the specific definition of property rights.

2. Ronald Coase

A.C. Pigou and other 20th century economists examined situations where an activity, such as a smokestack, from one individual's property affects the value of other individuals' properties.[83] To an economist, an *externality* is a non-budgetary factor beyond the control of an individual or business affected by the factor. Often, an externality is a choice made by one individual or entity that affects the welfare or productivity of another.[84] Thus, the

[81] (Locke, John. [1690] 1991. *Two Treatises of Government,* ed. P. Laslett. Cambridge: Cambridge University Press. p. 329.
[82] Adam Smith, *The Wealth Of Nations* 456 ¶ 9. "Every individual… neither intends to promote the public interest, nor knows how much he is promoting it . . . he intends only his own security; and by directing that industry in such a manner as its produce may be of the greatest value, he intends only his own gain, and he is in this, as in many other cases, led by an invisible hand to promote an end which was no part of his intention."
[83] See A.C. Pigou, *The Economics of Welfare* (McMillan, 1920).
[84] On the concept of externalities, see Paul A. Samuelson, "The Pure Theory of Public Expenditure," 36 *Review of Economics and Statistics*386–389 (1954).

upwind smokestack affects the value and perhaps the health of downwind property owners and individuals. An individual may enjoy listening to loud music, but the noise may interfere with the serenity of his neighbor. Similarly, a transmitter that emits substantial energy in a spectrum band may interfere, even harmfully, with other users in the band or with users in adjacent bands.

a. The Coase Theorem and real property

Practically all instances of harmful spectrum interference can be viewed as economic externalities: the choices of one set of spectrum users affect the spectrum choices of other potential spectrum users. Professor Coase addressed this interference in both his 1959 and 1960 papers and developed an analysis that is widely called the "Coase Theorem": in the absence of transactions costs, parties will negotiate away externalities with one party purchasing the other's rights.[85] Part of the theorem relies on the economic concept that one party that can put a resource to a higher and better use than another party will, in the absence of transaction costs, purchase or negotiate the property rights to do so. Of course, the initial allocation of rights and transactions costs matter in determining the final allocation outcome, with transactions costs increasing with the number of affected parties. The general principle, however, that the private parties with property rights have incentives to resolve--and can and will, with low transactions costs, actually resolve--the externalities between themselves without government administration is a powerful outcome.[86]

[85] See particularly, R.H. Coase (1960).
[86] On the notion that disputes can be resolved without law, see Robert Ellickson, *Order Without Law: How Neighbors Settle Disputes* (Harvard, 1991).

Even assuming that transactions costs prevent the parties from negotiating an agreement regarding an externality, law and economics provide guidance about liability and damages where property rights are present.[87] Thus, in terms of liability, the smokestack example can be viewed through the lens of tort, trespass, nuisance, and other legal structures depending on whether the smokestack owner has the initial property right to emit smoke or not. Remedies may involve damages compensation, easements, other transactions between the parties, etc. The same analysis could follow in terms of property rights to use all forms of spectrum, including spectrum without licenses. Thus, if the spectrum rights specify the accepted rules to the use of spectrum without licenses and under which circumstances, the Coase Theorem solution without government administration should follow.

b. The Coase Theorem and spectrum without licenses

Real property and licensed spectrum have a finite and knowable number of assignments and parties with assigned rights. At least conceptually, the usual Coase Theorem easily applies for coordination and dispute resolutions among those finite number of property holders with assigned rights to spectrum licenses.[88]

Does the Coase Theorem apply to spectrum without licenses as well? Spectrum without licenses has neither a finite nor a knowable number of assigned parties. At first blush, the Coasian framework would appear inapplicable. But there is an approximate parallel of

[87] See, e.g., Richard Posner, *Economic Analysis of Law* (Little Brown & Co., 1973).
[88] RH. Coase (1960).

the Coase Theorem through the IEEE working groups and other standards-settings bodies.[89] These groups, not government, decide the standards for the use of various types of spectrum, including many forms of spectrum without licenses. Although the FCC retains ultimate regulatory authority over spectrum and determines the rules for regulated spectrum, both with and without licenses, much of the diffusion of technical information and the negotiation among interested parties on technical issues related to unlicensed technologies now takes place in IEEE working groups open to the public. The IEEE standards often assign implicit property rights to spectrum users.

As with any meetings, the IEEE working groups have substantial transaction costs. But, consistent with Coase's Theorem, entities capable of putting spectrum to higher and better valued uses have substantial incentives to participate in the IEEE process in a manner that would enable the higher-valued uses.

To reduce the likelihood of conflicting uses of spectrum in either licensed or other uses, interested parties participate in, and rely upon, standards-setting bodies such as the IEEE. The standards-setting bodies can provide, and have provided, coordinating engineering standards and technical parameters among various interested parties to reduce the likelihood of conflicting uses. The standards set by those organizations are consistent with voluntary agreements among property holders.

3. Paul Samuelson

[89] https://www.ieee.org/index.html.

An extreme form of an externality is a public good. Richard Musgrave expanded the analysis, and Paul Samuelson generalized notion and described the mathematics of assessing what became known as pubic goods.[90] Public goods are contrasted with private goods, and public goods usually have at least two, and sometimes three, characteristics: non-excludability, non-rivalry, and non-depletability. A non-excludable good is one that no individual can be excluded from consuming. National defense is a common example of a non-excludable good; an art museum, by contrast, is excludable. Non-rivalrous means that one individual's consumption of a good does not affect another individual's consumption. Non-depletable mans that a good, such as sunlight, cannot be depleted no matter how much is consumed. In contrast, once the ore in a mine is exhausted today, it cannot be replaced tomorrow.

It would be easy to look at spectrum, whether licensed or not, and assume that it is a pure public good. It is not. While spectrum is non-depletable—no matter how much it is consumed today, no less spectrum is available tomorrow--other public good characteristics do not hold. Elements of the use of spectrum not subject to a license are at least partially excludable as can easily be seen with the many commercial applications of password-enabled WiFi.[91] Similarly, like all other forms of spectrum, whether licensed or not, it is congestible. One can see the speed of WiFi slow when several guests are in a

[90] Paul A. Samuelson, "The Pure Theory of Public Expenditure," 36 *Review of Economics and Statistics* 386–389 (1954).

[91] For a good discussion of the partitions and ranges of public goods, see James M. Buchanan, *The Demand and Supply of Public Goods,* 1968, Liberty Fund, Inc., Indianapolis, Chapter 9, available at http://www.econlib.org/library/Buchanan/buchCv5c9.html#Ch.%209,%20Which%20Goods%20Should%20Be%20Public.

home, all using the same WiFi system. Excludable and congestible, spectrum not subject to licenses and its applications are simply not pure public goods.

4. C.G. Hardin

The "tragedy of the commons" is a frequently-used idiom to describe the over-use of a depletable, excludable resource.[92] The tragedy of the commons is not a reference to pure public goods, for which there cannot be overuse or over consumption. In the case of "tragedy of the commons," the problem is precisely over-use from the absence of efficient exclusion mechanisms. The most frequently used example of "tragedy of the commons" is the overgrazing of a common field available to anyone such that the grass is all eaten and the field becomes of no value for grazing for a period of time. Other typical examples are fisheries where overfishing leads to such declining fish populations that the fishery no longer is of value, sometimes permanently depleting the population. The idiom reflects an inefficient overuse of such a resource. The economic solution invariably is to restrict entry into the field.

The "tragedy of the commons" has a polar opposite, the "tragedy of the anticommons" in which property owners can too easily exclude others from a common resource, leading to

[92] The clearest initial use of the concept is C.G. Hardin, "The Tragedy of the Commons," *Science* 1968, vol. 162, 1243–1248 available at doi:10.1126/science.162.3859.1243. Hardin referenced W. F. Lloyd, *Two Lectures on the Checks to Population* (Oxford Univ. Press, Oxford, England, 1833), reprinted (in part) in *Population, Evolution, and Birth Control*, G. Hardin, Ed. (Freeman, San Francisco, 1964), p. 37. Hardin also cited A.N. Whitehead for the definition of "tragedy." A. N. Whitehead, *Science and the Modern World,* 17 (1948). Hardin actually misuses the concept to support a Malthusian view of population growth ignoring technological change.

an underuse of the resource. Michael Heller popularized the concept of anticommons with an example of empty storefronts in post-Communist Moscow. [93]

Is spectrum not subject to licensing an example of tragedy of the commons? While market-based limits are available for devices not requiring licensed spectrum, and limits to their use in a private property realm,[94] literally billions of devices today use spectrum not subject to license. For these reasons, it is tempting to label spectrum applications not subject to license as suffering from the tragedy of the commons. The idiom is inexact.

First, the canonical examples of tragedy of the commons purely involve *repeated* and *identical* uses: too many undifferentiated cows or sheep in the commons; too many undifferentiated fishermen fishing for the same undifferentiated fish. Although repeated use of the same spectrum application can lead to congestion, such as WiFi in the 2.4 GHz band, disputes involving spectrum not subject to license also often include not only congestion among similar uses but also interference between different and *conflicting* uses. This is a coordination issue that could involve no more than two users, while the spectrum not subject to license might easily accommodate a much large number of non-conflicting uses.

[93] Michael A. Heller, "The Tragedy of the Anticommons: Property in the Transition from Marx to Markets," 111." Harvard Law Review 3 (1998): 621-88, available at .http://repository.law.umich.edu/cgi/viewcontent.cgi?article=1608&context=articles.

[94] Here, by private property realm, I mean a private home where the public is not necessarily invited. I do not mean a business located on private property that opens itself up to the public, such as a hotel or restaurant.

Second, for a true tragedy of the commons, there usually is at least temporary if not permanent depletion. With spectrum, challenges are primarily congestion, but not depletion. Unlike an endangered species or a fishery, spectrum need not regenerate itself. The use of spectrum today will not reduce its availability tomorrow or next year.

With conflicting spectrum uses, the result is sometimes an *underuse* of spectrum. That is, because of a lack of coordination among unlicensed users or between licensed and unlicensed users, fewer spectrum applications are used than would be the case with better coordination. The uses of some unlicensed bands tend to be well coordinated through standards-based technological means. But, other bands, such as the 900 MHz band, with conflicting uses, are likely underutilized. On the other hand, the underuse of spectrum is not a pure anticommons. Businesses and individuals typically do not block spectrum use, and any such efforts are unlawful.[95]

A pure tragedy of the commons can be resolved by limiting entry, but a pure tragedy of the commons is rarely the precise challenge facing spectrum use. The more frequent problem in each band is not so much overuse as conflicting and uncoordinated use. The solution is to resolve the conflicting uses, usually through standards-setting organizations.

[95] The FCC prohibits both blocking devices for both cellular and WiFi devices. *See, e.g.*, "WARNING: Wi-Fi Blocking is Prohibited," FCC Enforcement Advisory, DA 15-113, 30 FCC Rcd. 387 (January 27, 2015), available, at https://apps.fcc.gov/edocs_public/attachmatch/DA-15-113A1.pdf;. "Marriott International, Inc. and Marriott Hotel Services, Inc.," Order, DA 14-1444, 29 FCC Rcd. 11,760 (October 3, 2014), available at https://apps.fcc.gov/edocs_public/attachmatch/DA-14-1444A1.pdf;; FCC News Release, "FCC Fines Smart City $750,000 for blocking Wi-Fi," (August 18, 2015), available, at https://apps.fcc.gov/edocs_public/attachmatch/DOC-334905A1.pdf;; FCC News Release, "FCC to Fine Hilton Hotels for Failure to Comply with Wi-Fi Blocking Investigation," (November 2, 2015), available, at https://apps.fcc.gov/edocs_public/attachmatch/DOC-336102A1.pdf.

Resolving conflicting spectrum uses might be a relatively simple technological problem if (1) all technologies employing spectrum could coordinate with one another; and (2) technology were constant. But not all technologies that employ spectrum coordinate with one another. Moreover, even the technologies that can coordinate are constantly changing. Thus, each device in a new vintage of technology may be able to coordinate and resolve conflicts with other devices in the same or similar vintage, but not necessarily with older vintage technologies or with entirely different applications, or with technologies yet to be deployed.

5. Armen Alchian

Economists have long examined the concept of property. While formal definitions vary, Armen Alchian, one of the leading economists on property rights,[96] identified three characteristics—often called property rights-- associated with a resource or asset:

> "(1) exclusivity of rights to choose the use of a resource,
>
> (2) exclusivity of rights to the services of a resource, and
>
> (3) rights to exchange the resource at mutually agreeable terms."[97]

Notice that economic property rights are not defined specifically in terms of property or even ownership of an asset but rather in broader concepts of "rights" to choose and to benefit from certain activities. Property rights are rarely absolute, and, as will be shown below, they are not absolute for spectrum, including spectrum without licenses.

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[96] Armen A. Alchian, "Some Economics of Property Rights," 30 IL*Il* Politico 4 (1965):), 816–29, available at. http://www.jstor.org/stable/43206327;; *see also* Armen A. Alchian and Harold Demsetz, "The Property Right Paradigm," 33. The Journal of Economic History 1 (1973): 16-27, DOI: . doi:10.1017/S0022050700076403.

[97] Armen A. Alchian, "Property Rights," The Concise Encyclopedia of Economics, available at http://www.econlib.org/library/Enc/PropertyRights.html. See also other works by Alchian.

An entity may have the economic property rights of an asset without actually owning it much as an entity may have legal control of an asset without complete or even partial ownership. Although property rights and control are related, they are not identical. One or more of the three property-rights characteristics may be limited, and property rights are still said to apply. The FCC has addressed how to identify control, or at least corporate control, for spectrum under wireless licenses using the three Alchian conditions, without "exclusivity."[98] The FCC, however, has not identified control for spectrum without license.

These three characteristics—determination of use, benefitting from use, and right to transfer or exchange—are the foundation of economic principles of property rights. The three principles reinforce one another. Thus, opportunities to benefit from the use of an asset or to transfer it to others are substantially limited if an individual cannot effectively control its use. Similarly, if one cannot benefit from its use or transfer an asset, the economic value of determining the use of an asset is limited.

[98] "Non-broadcast and General Action Report No. 1142," Public Notice, 12 F.C.C.2d 559 (Feb. 6, 1963) ("(*Intermountain Microwave*").). The factors in *Intermountain Microwave* are:
(1) Does the licensee have unfettered use of all facilities?
(2) Who controls daily operations?
(3) Who determines and carries out the policy decisions, including preparing and filing applications with the Commission?
(4) Who is in charge of employment, supervision, and dismissal of personnel?
(5) Who is in charge of the payment of financing obligations, including expenses arising out of operation?
(6) Who receives monies and profits from the operation of the facilities?
See also "Application of Ellis Thompson Corporation," CC Docket No. 94-136, Summary Decision of Administrative Law Judge Joseph Chachkin, FCC 95D-14, 10 FCC Rcd. 12,554 (Nov. 14, 1995); "Application of Baker Creek Communications, L.P.," Memorandum Opinion and Order, DA 98-1921,, 13 FCC Rcd. 18,709 (Sept. 22, 1998).

In the remainder of the paper, I will use these three property concepts in examining rights in spectrum.

B. Property right concepts in spectrum are not limited to licenses

Discussion of property rights concepts and spectrum are common. Many commentators have noted a tension between licensed spectrum and other spectrum,[99] with licensed spectrum characterized with property rights[100] and other spectrum characterized as a "commons" largely devoid of property rights.[101] Writing in 2012, Yochai Benkler painted the two polar opposites of property rights and commons as follows:

> Over the course of the past fifteen years, substantial literature has developed addressing the basic choice between a "spectrum property" model of exclusive licenses defined primarily in terms of frequency and power, and a model based on equipment and services that do not depend on exclusive access to any frequency but rather share a given range of frequencies under a set of generally-applicable coordination rules.[102]

Benkler pointed to the empirical success of unlicensed spectrum as being the superior "baseline" rather than the more property-like rights of licensed spectrum.[103]

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[99] *See, e.g.*, Gerald R. Faulhaber and David Farber, "Spectrum Management: Property Rights, Markets, and the Commons," Wharton School Working Paper (2002),, available at http://assets.wharton.upenn.edu/~faulhabe/SPECTRUM_MANAGEMENTv51.pdf.

[100] *See, e.g.*, Thomas W. Hazlett, "Assigning Property Rights to Radio Spectrum Users: Why Did FCC License Auctions Take 67 Years?," 41*?* The Journal of Law & Economics 52 (Oct. 1998): 529, available at http://www.jstor.org/stable/10.1086/467402?seq=1#page_scan_tab_contents; Thomas1998). Thomas W. Hazlett and Sarah Oh, "Exactitude in Defining Rights: Radio Spectrum and the 'Harmful Interference' Conundrum," 28 Berkeley Technology Law JournalTech. L.J (2013), available at http://scholarship.law.berkeley.edu/btlj/vol28/iss1/6.

[101] *See, e.g.*, Yochai Benkler, "Open Wireless Versus Licensed Spectrum: Evidence from Market Adoption," 26 Harvard Journal of Law & Technology 1 (2012),, available at http://jolt.law.harvard.edu/articles/pdf/v26/26HarvJLTech69.pdf.. For a list of commons advocates, see particularly n. 76. *See also* Yochai Benkler, "Overcoming Agoraphobia: Building the Commons of the Digitally Networked Environment," 11 Harvard Journal of Law & Technology 2 (1998), available at http://jolt.law.harvard.edu/articles/pdf/v11/11HarvJLTech287.pdf.

[102] Benkler, "Open Wireless Versus Licensed Spectrum: Evidence from Market Adoption," 83.

[103] *Id.*

The issue is not on the comparative merits of licensed and other spectrum or whether one should be expanded at the expense of the other. The notion that there is a "basic choice" is a false choice. Both are and will remain important and necessary parts of spectrum in the United States. Nor is it accurate to characterize spectrum without licenses as lacking property rights.

It turns out that, much like licensed spectrum, spectrum without licenses already offers a collection of rights and concepts that, in a practical sense, bears strong similarities to a traditional property regime. Without these characteristics, spectrum without licenses has been, and would be, far less valuable and far less innovative.[104]

Further, the applicability of property rights concepts to licensing has limitations. The notion of "licensing" spectrum is both recent and not universal. Licensing has never been applied to the vast majority of the spectrum. Even in the bands of spectrum that are partly licensed (9 kHz – 275 GHz), uses without licenses abound.

The very process by which the federal government began widespread licensing of spectrum, the Radio Act of 1927, was an extraordinary exercise of government *expropriation* of much of the radio spectrum and the dissolution of court-recognized property rights for radio stations.[105] Licensing of spectrum began not as a means of

[104] Applications of spectrum without licenses languished when the FCC engaged in command-and-control review of all new technologies.
[105] *See* Hazlett, "Optimal Abolition of FCC Spectrum Allocation."

expanding property rights but of dissolving them. Although licensed spectrum has recognized elements of property rights, those elements are limited. In the United States, federal law clearly retains titular property rights for the federal government, not the licensee.[106] Thus the government retains for itself the following rights with respect to spectrum:

> (1) Even for spectrum that has been licensed, the federal government can choose the broad category of use of spectrum, ultimately including unlicensed spectrum within bands that are regulated. Each band of regulated spectrum is allocated for a specific use chosen by the federal government. Licensees cannot use the spectrum for other purposes. Moreover, much of spectrum licensed for non-federal uses is also shared with federal users, for whom the federal government determines usage. The federal government also shares spectrum in bands used by Part 15 devices, and the federal government itself is a major user of unlicensed devices.
>
> (2) Although the federal government does not directly enjoy the services of spectrum by licensed users, it does enjoy the services of the same spectrum as federal users who have access to, and share, the same spectrum as used by licensees. Moreover, the federal government benefits from the services even of the licensed uses both through license fees to the FCC and through federal taxes on corporations and other entities that benefit from the licenses. The federal government also benefits from the services of unlicensed spectrum applications through federal taxes on corporations and other entities that benefit from the unlicensed applications.

[106] 47 U.S.C. § 301.

(3) Although the vast majority of spectrum licenses are exchanged freely without interference from the FCC, the federal government ultimately retains for itself the right to review and control the exchange of all spectrum licenses.

As limited as are the property rights in spectrum licenses today, the current bundle of property rights associated with licensed spectrum is a substantial improvement on the more limited set of rights available just a few decades ago.

C. From a free market perspective, the federal government should be involved in clarifying property rights concepts

Identifying property rights concepts is an important function in which the government has a major role. Milton Friedman once wrote:

> "A government which maintained law and order, *defined property rights*, served as a means whereby we could modify property rights and other rules of the economic game, adjudicated disputes about the interpretation of the rules… such a government would clearly have important functions to perform."[107] [emphasis in italics added]

Property owners and other private parties influence the definition of property rights concepts as well. Defining property rights concepts is important, as Friedman noted: "[I]n many cases, the existence of a well specified and generally accepted definition of property is far more important than just what the definition is."[108] In other words, the terms "property rights" and "property right concepts" do not have fixed meanings, but can describe a variety of regimes with differing combinations of separate rights, which may be present in varying degrees and which may change over time. Therefore, the task of identifying property rights concepts is more than simply saying "this is property and

[107] Milton M Friedman, *Capitalism and Freedom* 34 (1962).
[108] *Id.* 27.

this is not"—rather, it involves the subtler task of clarifying specific rights that belong to a given rights "bundle." This clarification itself will serve to facilitate use and to limit disputes.

Friedman, of course, did not trust a matter as important as property rights entirely in the realm of the government. As Friedman noted, it was but for the government to "adjudicate disputes about the interpretation of the [property right] rules." Private parties including property owners would, and have, continue to dispute and to influence the definition and boundaries of property rights.

The robust academic discussions of property rights concepts and spectrum in the United States are inextricably linked. With his 1959 "The Federal Communications Commission," Coase explained the superiority of allowing property rights concepts in broadcast licenses and exposed the enormous harm from administrative processes in two areas: (1) the allocation of spectrum licenses; and (2) the determination of the uses of spectrum to avoid interference.[109] Professor Coase's article on property rights and spectrum spawned a series of articles of his own[110] as well as generations of economists.[111]

Much of Professor Coase's intellectual heritage in this area has focused on *licensed* spectrum and the ultimate creation of auctions for spectrum transferred from the

[109] Coase, "The Federal Communications Commission," *supra*,." 1-40.
[110] Coase, "The Problem of Social Cost," *supra*, ."1-44.
[111] See particularly the work of Thomas W. Hazlett.

government holdings to private use.[112] Although some scholarship has focused on the property rights tension between licensed and other spectrum, little attention has been dedicated to the pure property rights concepts of spectrum without licenses.[113] In part, this absence of focus on spectrum without licenses may be the artifact that, in 1959, there were relatively few regulated applications of other spectrum. But Professor Coase himself, in explaining why administrative solutions are inefficient and in describing the economic solution of property rights to spectrum, made no distinction between licensed and other spectrum. (Of course, in 1960, most spectrum of commercial interest was licensed.) To Coase, it was important to "delimit[] the rights of operators to transmit signals which interfere, or might potentially interfere, with those of others." The same should apply no less to any use of spectrum, not just to licensed applications. Effectively, as we shall see later, in 1989 the FCC followed Professor Coase's advice from 30 years earlier.

A casual reader might reach the following incorrect conclusion: *All relevant property rights concepts for all assets are already defined, and the absence of clearly defined property rights concepts is an indication that they will never develop*. But the absence of clearly defined property rights concepts is not an aberration; it is all too common, particularly with new technologies such as those dependent on spectrum without licenses. As it turns out, spectrum without licenses has already obtained certain property rights

[112] Effectively, market mechanisms including auctions had been in use for years to transfer spectrum from one private user, such as a broadcaster, to another.

[113] Doug Brake sees Coase as support for unlicensed spectrum, but more from a pragmatic perspective, rather than a property rights perspective. *See* Doug Brake, "Coase and WiFi: The Law and Economics of Unlicensed Spectrum," The Information Technology & Innovation Foundation (ITIF January 2015), available, at http://www2.itif.org/2015-coase-wifi.pdf.

concepts, and clarifying those property rights concepts further would be beneficial. Property rights concepts in spectrum in the United States have evolved substantially in the past century and continue to do so today. This paper provides a framework for examining those property rights concepts in spectrum, particularly in spectrum not subject to licensing.

D. The Incompleteness of property rights

It would be convenient if the Alchian property characteristics—to choose the use of an asset, to benefit from the use, and to benefit from transactions of the asset—were unalloyed and easily observable in all assets. They are neither unalloyed nor easily observable. It would also be convenient if an asset unambiguously had all—or none—of the elements of property rights as described by Professor Alchian. We could then speak of assets with pure property rights and those without.[114]

In practice, few if any assets—not even land or licensed spectrum—have all of the elements of property rights. Practically all assets may be considered incomplete in their property rights characteristics. If one looked carefully, some property rights characteristics are present in an asset; others are not; and rarely does anyone bother to look closely at the property rights characteristics of most assets.

Conversely, few assets are entirely devoid of at least some elements of property rights. Even in a benighted country such as North Korea, individuals are left with some limited

[114] Benkler, "Open Wireless Versus Licensed Spectrum: Evidence from Market Adoption," 83.

control over personal items. Even under the most repressive regimes, some elements of property rights concepts can be found in spectrum.

V. SPECTRUM USAGE DECISIONS ARE MADE BY ZONING AUTHORITIES, MANUFACTURERS, SERVICE PROVIDERS, CONSUMERS, AND ENTERPRISE CUSTOMERS

Property rights analyses of assets depend on the authority to make decisions. The Coasian framework depends on agents with the authority to buy and sell assets to reach efficient outcomes. The Alchian framework depends on agents with (1) authority to determine use of an asset; (2) opportunity to benefit from that use; and (3) authority to benefit from transactions. With many assets—such as a tract of land or a gold coin—the owner of the asset is usually the person responsible for all three of the Alchian characteristics. With spectrum, identifying the decision maker or the responsible party is far more complicated.

With the exceptions of the common law rights for sound and light, the decision maker for the use of unregulated audible or RF spectrum—such as audible sound and visible light—is no different today than it has been for time immemorial. Individuals and property owners have certain rights to access to—as well protections from—light and sound.

Regulated spectrum is quite different. Most property rights analyses are performed from the perspective of the property owner. The technical ownership of spectrum, even for licensed spectrum, is in most instances the federal government.[115] Decisions about the

[115] See discussion above regarding the 1927 Radio Act and Communications Act of 1934. I will not address issues of air rights here.

usage, benefit from usage, and transactions of regulated spectrum take place in at least four different steps, each conditional on the prior set of decisions: zoning decisions, manufacturing decisions, service provider decisions, and consumer and enterprise customer decisions. Few of these decisions are made by the technical spectrum owner, the federal government.

A. Zoning decisions

Various government authorities limit the lawful use of various assets and consequently, the ability to benefit from such uses and even to sell assets. Thus, zoning boards will designate various parcels of land for residential use, others for retail, and still others for industrial uses. A house may be a "person's castle," but zoning ordinances may limit the number of residents it may have and may prohibit its use as a commercial location, or apply any number of restrictions on its use. These zoning restrictions limit the range of choices a property owner may have, but they do not entirely eliminate the value that choice of use has to a property owner. Similar zoning restrictions affect the use of all types of regulated spectrum, both licensed and other.

Each national government has its own allocations, which conform with the International Telecommunications Union's allocations to the extent needed due to international treaties, but that differ with regard to domestic priorities, as well as domestic assignments for licensed spectrum. NTIA decisions govern federal usage. The FCC through regulations makes decisions about the permissible characteristics of non-federal spectrum usage. Characteristics include use restrictions, power limits, band plans, transmission requirements, etc. Zoning decisions reflect statutory requirements, known technology,

and the requests and representations of affected parties. These zoning decisions determine the limits of how spectrum may be used and how one may benefit from such use and even whether one may benefit from transactions involving spectrum. Zoning affects these three factors that reflect the property rights concepts in spectrum. While zoning decisions are not by themselves exercises in property rights, the zoning decisions affect the spectrum property rights and concepts of others.

Zoning decisions at the FCC—and technical standards at the IEEE and other standards-setting bodies—affect all regulated spectrum, both subject to license and not. It would be incorrect to say that one type of spectrum is consistently more heavily zoned than another; all bands face zoning regulation. The FCC compounds the problem of zoning by engaging in industrial policy. It chooses a particular use or application of the spectrum in some places rather than allowing the licensee or user to choose the highest and best use from its perspective. It even chooses a particular technology or band plan in some cases such as dedicated short-range communications. Unlike land, which is primarily zoned at the regional local levels, spectrum is regulated at the national level.

B. Manufacturing decisions

Unlike most other assets, regulated spectrum requires manufactured equipment for use and benefit from that use. Equipment manufacturers for transmitters and receivers that use spectrum compete in a global market and, conditional on the zoning decisions described above, manufacture many products that can operate lawfully in the United States. These manufacturing decisions affect the use of spectrum by making available equipment that can operate in various spectrum bands.

Manufacturers produce equipment that complies with zoning rules for both licensed and unlicensed spectrum—sometimes on the same device such as a cell phone with both licensed spectrum and Wi-Fi capability. The manufactured equipment includes devices that would be acquired only by a small number of large businesses such as a broadcast television transmitter as well as consumer devices that are sold to hundreds of millions of consumers globally, such as smart phones, Bluetooth devices, and Wi-Fi routers.

Available equipment changes in response to changing zoning decisions described above and to rapidly changing technology. Even without zoning rule changes, the characteristics of available equipment are constantly changing. Equipment manufacturing decisions reflect zoning requirements described above, known technology, the requests and representations of affected parties, the costs of manufacturing equipment, and the market demand for equipment. Available equipment determines how spectrum may be used and influences how individuals can benefit from the use of spectrum.

The manufacturing decisions affect all regulated spectrum, both subject to license and not. It would be incorrect to say that one type of spectrum enjoys better manufacturing options than another; all bands have manufacturing opportunities. Still, there are far more devices manufactured for unlicensed spectrum than manufactured for licensed spectrum, reinforcing the notion that unlicensed spectrum has substantial property rights and economic value.

C. Service provider decisions

Service providers make decisions about the use of spectrum and benefit from use by employing spectrum-dependent equipment to offer services to the public. These services include broadcasting, mobile wireless services, satellite services, WiFi services, etc. Some types of services, such as broadcasting services, cellular network services, and satellite services, require substantial capital investments and are offered only by large companies financially capable of making such investments. Other types of services, such as Wi-Fi services and Bluetooth services, can be offered by small businesses and even by consumer households.

The investment decision by chipmakers, however, is similar. A chipmaker must make a large investment to make a new chip, for a combination of licensed and unlicensed bands. In many ways, this investment is a bet that some or all of the bands will support a market for devices that have not yet been built.

A local area network with a Wi-Fi hotspot can be offered either by a large enterprise, a small business, or a modest-income household. Businesses make decisions about spectrum use not only by the types of equipment purchased and the location of that equipment, but also by decisions about how to manage information traffic through a broader network. Information networks, for example, can consist of various fiber links as well as wireless spectrum links, some of which may be licensed and others of which are not. The specific types of services that may be offered are largely dependent on the equipment available from manufacturers as described above. Service provider decisions

reflect zoning requirements described above, available equipment, known technology, the requests and representations of major customers, the costs of providing services, and the market demand for those services.

Service provider decisions may differentiate between licensed and other spectrum. A service provider may choose to use licensed spectrum or spectrum for various parts of its network. The licensed spectrum it uses may be licensed to itself or to a third party under lease arrangements. In some instances, a service provider may also substitute unlicensed spectrum applications for licensed applications, and vice versa.

D. Consumer and enterprise customer decisions

Finally, consumers and enterprise customers make decisions about the use of spectrum by choices they make about how and when to use spectrum-dependent equipment. A generation ago, much of spectrum usage was in the broadcast band with radio and televisions stations transmitting one-way signals, whether or not consumers were listening or watching. Today, the applications of spectrum usage are much more varied with substantial usage, some of which remains one-way, but much of which is two-way. Consumers and enterprise customers make decisions on the use of spectrum-based equipment depending on available services and equipment, the prices, and the qualities of service and equipment.

Consumers and enterprise customers make decisions about all regulated spectrum, both subject to license and not. It would be incorrect to say consumers and enterprise customers focus on one type of spectrum and not another. Consumer and enterprise

customers are often not aware of the regulatory status of spectrum, and their choices affect all types of spectrum. Of course, consumers respond to costs associated with the use of spectrum, and consumers know to switch their cell phones to Wi-Fi—or set up devices to do so automatically—so they don't have to pay or reach caps. Similarly a logistics company knows that it must pay for CMRS-based RF IDs but not for Wi-Fi or Bluetooth-based RFIDs and builds that into the cost structure.

For spectrum in the United States, both licensed and other forms of spectrum, the general path over more than the past century has been towards clearer articulation of what turns out to be property rights concepts. Yet outside of licensed spectrum, the identification and discussion of property rights concepts in spectrum in the United States is rare. In sections VI-IX below, I review respectively the property rights characteristics for spectrum for: (1) choice of use, (2) benefit from use, and (3) benefit from transactions. Although important decisions are made by zoning authorities and manufacturers, the actual users of spectrum are service providers, consumers, and enterprise customers. I will focus on them in the remaining sections.

VI. THERE IS LITTLE DIFFERENCE BETWEEN LICENSED AND OTHER SPECTRUM IN THE PROPERTY RIGHTS CONCEPT OF CHOICE OF USE

In this section, I examine the choice of use of regulated spectrum for both service providers and for consumers and enterprise customers.[116] There is little difference in choice of use between licensed spectrum and spectrum not subject to license.

A. Freedom of choice and limitations on such freedom

"Free to choose," the first of the Alchian property rights concepts, is such a fundamental concept of economics and such a self-evident proposition that Nobel Laureate Milton Friedman used it as the title of one of his most popular books.[117] Those who are free to choose have economic opportunities; those who are not free lack them.

Freedom to choose is often associated with property, and the Alchian property concept of choice is ancient and often phrased in absolute terms. At a time when nobility had extraordinary powers to do much as they chose, Sir Edward Coke stated in the 17th century that property rights extended to ordinary houses and their owners:

> For a man's house is his castle, *& domus sua cuique est tutissimum refugium;* for where shall a man be safe, if it be not in his house?[118]

A nobleman could choose what to do in the safety of his castle. So too could an ordinary man in his own home. This is not to say that an individual is free to engage in criminal

[116] Manufacturers, service providers, consumers, and enterprise customers all have substantial choice of use for unregulated spectrum.
[117] Milton Friedman &, Rose D. Friedman, *Free to Choose: A Personal Statement*, 1990.*choose: a personal statement*.
[118] Edward Coke, *The Third Part of the Institutes of the Laws of England* 162 (1644), available a).t http://www.bartleby.com/73/859.html.

activities such as murder in a home, but rather that government dictation of choices among otherwise lawful activities does not extend to the home.

The concepts of the primacy of the home and property and the choice of use in the 17th century were straightforward and seemingly absolute. Property concepts, including choice of use, are much more nuanced today. If the Alchian property concept of choice of use of an asset were a simple test, one could look at various types of assets, including different categories of spectrum, and designate whether the test is met. But most concepts of the choice to use an asset, particularly spectrum-related assets, are not simple.

Generally, a user of spectrum can determine the use of spectrum consistent with Alchian property rights. Choice of use must be consistent with zoning restrictions, which are ubiquitous for spectrum. Even a person in her own home, otherwise a castle, is limited by the federal government in how regulated spectrum may be used. Thus an individual cannot set up an unlicensed broadcast station beaming from one's home. Nor can an individual use regulated spectrum except as prescribed by regulation. But that is not the case for unlicensed uses of spectrum. Here an individual is free to choose to use unlicensed applications as she sees fit, particularly in the realm of her castle.

The federal government influences decisions about spectrum usage in many different ways in addition to those described above. For example, the federal government allocates the same band of spectrum for multiple purposes. Even after allocations are set, the

federal government has advocated for various forms of "spectrum sharing" that further erode decisions available to spectrum users.[119]

The federal government also provides enforcement mechanisms through both the courts and the Commission to resolve disputes surrounding spectrum use, including disputes involving interference. These roles of both enforcement and dispute resolution for spectrum distinguish the American government structure from that of many other countries where spectrum users—whether licensed or not—have few if any legal remedies to resolve disputes.

B. Determining choice of use

Since 1912, the federal government has allocated and classified the use of regulated spectrum. Within each allocation are specific limitations on the purposes, power limits, out-of-band emissions, and other characteristics of regulated spectrum. These allocation limitations set by the federal government pertain to both licensed and other forms of regulated spectrum. In the past two decades, the FCC has increasingly relied on flexibility in use, delegating usage choices to users of regulated spectrum to the extent that harmful interference is avoided. For example, the FCC has granted ancillary terrestrial component flexibility for many satellite service providers to offer terrestrial services as well. Commercial mobile radio services and other terrestrial mobile services have flexibility to offer a range of services including mobile broadband services.

[119] CSMAC, National Telecommunications & Information Administration, U.S. Department of Commerce, https://www.ntia.doc.gov/category/csmac.

Since 1938, manufacturers, service providers, and consumers have had some rights to determine usage of Part 15 devices and spectrum. Between 1938 and 1989, the federal government determined the specific use of regulated spectrum for Part 15 devices. Since 1989, usage of Part 15 devices and unlicensed spectrum has been flexible, subject to standards setting.

Even with the limitations of federal allocations and available manufactured equipment, service providers have considerable flexibility in how to combine equipment for various purposes including forming networks. Commercially available networks are increasingly complex and rarely the product of either purely licensed or purely non-licensed spectrum or applications. Thus, television programming was once offered almost exclusively on licensed spectrum but today is predominantly received by consumers either through cable, satellite, or broadband services. Television programming may ultimately reach a consumer through a combination of fiber and/or coaxial cable as well as licensed and unlicensed spectrum. Similarly, mobile communications services today are rarely offered on a purely licensed or unlicensed basis but on a combination of many different types of spectrum.

C. Excluding others

One of the usual characteristics of "choice of use" is the ability of a property owner or manager to exclude others from using the property. That is a common characteristic of real estate, and various forms of exclusion are possible under unregulated spectrum. The concept that a property owner can choose how to use it extends to excluding others from

the property. William Pitt, the Elder, stated the power of a property owner to exclude others including government as follows:

> The poorest man may in his cottage bid defiance to all the forces of the Crown. It may be frail—its roof may shake—the wind may blow through it—the storm may enter—the rain may enter—but the King of England cannot enter!—all his force dares not cross the threshold of the ruined tenement![120]

If the property owner could exclude the King of England, how much more so could he exclude an ordinary person.

But pure exclusion—where no one is allowed to use a band of spectrum in a geographic area—is far less a characteristic of regulated spectrum, whether licensed or not, in the United States. Geographic areas surrounding four federal radio astronomy monitoring stations are the closest concepts of pure exclusion zones across many spectrum bands in the United States.[121]

The FCC cannot by itself exclude federal users from most bands of spectrum, and NTIA cannot exclude non-federal users from most bands of spectrum.[122] The diffused structure of spectrum management ensures that no agency has the authority to exclude all others from spectrum. The result in part is that many federal and non-federal users are in the vast majority of spectrum bands. Allocations from each agency leave practically every band on spectrum with multiple allocations. On top of these formal allocations,

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[120] Henry Peter Brougham, *Historical Sketches of Statesmen Who Flourished in the Time of George III* 52 (1839), available at http://www.bartleby.com/73/861.html.

[121] *See* "Radio Astronomy and Spectrum Planning Options," NTIA Special Publication 98-35, U.S. Department of Commerce, § 4 (April 1998), available at See https://www.ntia.doc.gov/legacy/osmhome/reports/pub9835/Raspchp4.htm. .

[122] *See id.* (above.Various federal defense facilities also have exclusion zones in some spectrum bands surrounding them). .

unlicensed use and "sharing" arrangements result in substantial entry and potential usage of every spectrum band. The result, not surprisingly, often is congestion and interference.

The closest form of exclusion for spectrum among non-federal users is licensed spectrum. A licensee, usually a service provider, has exclusivity within the parameters of a license: spectrum band, power limits, emission characteristics, location, etc. The licensee, however, cannot exclude users—including governmental users—from using the same spectrum for lawful, non-licensed purposes. In practice, however, with the exceptions of 900 MHz and 2.4 GHz, most licensed bands have little unlicensed activity. The 900 MHz and 2.4 GHz and parts of the 5 GHz bands are sometimes referred to as "unlicensed bands" even though the first two are entirely licensed as well. In most instances, there are few if any forms of complete exclusivity.

From a consumer or enterprise customer perspective, the view of exclusivity of use likely does not vary with the regulatory status of spectrum. Consumers are largely unaware of the technical specifications of the spectrum they use, much less the regulatory status, and much less the exclusivity of use within that regulatory status.

D. The importance of standards-setting organizations in establish rights of use

In a society in which speakers spoke in one frequency, and listeners could hear only in a different frequency, spoken words would have no communications value. Similarly, if there were no visible light, human eyes would have little value. A world in which transmitters and receivers operated with uncoordinated signals would be a world with

little communications and a world with little in the way of rights of use in communications. Standard-setting bodies such as the IEEE provide for coordination of signals, not for two devices, but literally for billions of devices globally. The net result is substantially greater rights of use in communications, a property rights concept.

Demsetz explained that one of the primary purposes of property rights is "that of guiding incentives to achieve a greater internalization of externalities."[123] By that, Demsetz meant allowing the actual costs and benefits of effects to be incurred by those who cause the effects rather than by others. While there are no formal property rights in spectrum without licenses, the Demsetz article could easily be read to apply to standards-setting bodies that prescribe standards for all spectrum including spectrum without licenses.[124]

E. "Interference" and "Harmful Interference"

Part of property rights concepts for choice of use includes freedom from unlawful interference, or at least freedom from unlawful harmful interference.[125] The Commission has addressed both "interference" and "harmful interference." The original Communications Act of 1934 instructed the FCC to limit if not eliminate radio spectrum interference without limitation to harmful interference:

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[123] Harold Demsetz, "Toward a Theory of Property Rights," 57 The American Economic Review 2 (1967):),347-359, available a. t http://links.jstor.org/sici?sici=0002-8282%28196705%2957%3A2%3C347%3ATATOPR%3E2.0.CO%3B2-X.

[124] *Id.* (""An owner of property rights possesses the consent of fellowmen to allow him to act in particular ways. An owner expects the community to prevent others from interfering with his actions, provided that these actions are not prohibited in the specifications of his rights."). ."

[125] Not all interference, or even harmful interference, is unlawful. As Demsetz and others have noted, a competitor eroding the profits of another firm harms that firm, but such competition is not unlawful. Also, "[a]"n owner of property rights possesses the consent of fellowmen to allow him to act in particular ways. An owner expects the community to prevent others from interfering with his actions, provided that these actions are not prohibited in the specifications of his rights." *See* H. Demsetz, "Toward a Theory of Property Rights," 347-359.

> No person shall use or operate any apparatus for the transmission of energy or communications or signals by radio … when interference is caused by such use or operation with the transmission of such energy, communications, or signals from within said State to any place beyond its borders, or from any place beyond its borders to any place within said State, or with the transmission or reception of such energy, communications, or signals from and/or to places beyond the borders of said State.[126]

Moreover, the original Communications Act of 1934 also instructed the FCC to prevent interference "between stations and to carry out the provisions of this chapter."[127]

The concept of "harmful interference," as distinct from just "interference," does not appear until much later, such as the 1968 amendment in what became 302(a), written nearly a decade after the original Coase articles on the FCC.[128] Congress in subsequent years added many references to harmful interference, such as in 1997 when it added subsection (y) on harmful interference to Section 303.[129]

Under amendments to the Communications Act of 1934, the Commission is obligated to write rules to "prevent" "harmful interference" in radio communications.[130] Although a

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[126] 47 U.S.C. § 301.

[127] *See, e.g.*, 47 U.S.C. § 303(f) (""Make such regulations not inconsistent with law as it may deem necessary to prevent interference between stations and to carry out the provisions of this chapter.")..." *See also* Radio Act of 1927 § 4(f).).

[128] *See* Communications Act of 1934, 1968 Amendment, Public Law 90-379 § 302(a) ("The Commission may, consistent with the public interest, convenience, and necessity, make reasonable regulations governing the interference potential of devices which in their operation are capable of emitting radio frequency energy by radiation, conduction, or other means in sufficient degree to cause harmful interference to radio communications. Such regulations shall be applicable to the manufacture, import, sale, offer for sale, shipment, or use of such devices.")..

[129] *See* Balanced Budget Act of 1997, Public Law 105-33 § 3005 ("(y) Have authority to allocate electromagnetic spectrum so as to provide flexibility of use, if— (1) such use is consistent with international agreements to which the United States is a party; and
(2) the Commission finds, after notice and an opportunity for public comment, that— …
(C) such use would not result in harmful interference among users."). ."

[130] *See, e.g.*, 47 U.S.C. § 302(a) ("), "The Commission may, consistent with the public interest, convenience, and necessity, make reasonable regulations (1) governing the interference potential of devices which in their operation are capable of emitting radio frequency energy by radiation, conduction, or other

complete absence of interference in our complex environment is impossible, the Commission takes seriously its efforts to reduce, if not prevent, interference, particularly harmful interference. For much of the 20th century, this harmful interference usually involved different transmitters using the same technology and the same frequency at the same time in roughly the same location. Thus, there are rules to reduce many conflicts in the use of spectrum between licensed users within the same allocation, e.g., broadcasters in the same or adjacent channel.

The federal government has attempted to resolve these conflicts in various ways including: (1) precedence for ships in distress;[131] (2) different time usage for conflicting federal and non-federal users;[132] (3) licensing transmitters;[133] (4) and reserving specific bands of spectrum for specific uses on a case-by-case basis at the FCC. For both radio and television broadcasters, the FCC organized licenses for broadcasters using the same technology to reduce interference by spreading licenses geographically and across frequency bands.

In recent years, an increasingly common form of interference is between two entirely different applications and technologies, both attempting to use the same band of spectrum

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means in sufficient degree to cause harmful interference to radio communications…")…." For a discussion of the Commission's interpretation of distinguishing between "interference" and "harmful interference," see R. Paul Margie, "Can You Hear Me Now: Getting Better Reception from the FCC's Spectrum Policy," Stanford Technology Law Review (2003), available at https://journals.law.stanford.edu/stanford-technology-law-review/online/can-you-hear-me-now-getting-better-reception-fccs-spectrum-policy, 5.

[131] 47 U.S.C. § 320-323.

[132] 47 U.S.C. § 323.

[133] 47 U.S.C. § 301 and § 319.

at the same time. Below, I examine several examples involving devices using spectrum without licenses.

1. Part 15 Devices Accepting Interference

Part 15 devices use on a low-power basis spectrum that is otherwise allocated for other purposes. Formal allocations are made by the National Telecommunications and Information Administration ("NTIA") for federal users and by the FCC for non-federal users.[134] The result sometimes is interference by licensed users with unlicensed Part 15 devices and vice versa as indicated by public notices on unintentional interference with consumer products ranging from garage door openers[135] to baby monitors[136] as well as public notices forbidding intentional interference with Wi-Fi devices.[137] In many instances, the FCC has expressed concern and has sought to protect spectrum access, for incumbent unlicensed users.

2. 900 MHz and Location and Monitoring Service ("LMS")

Adopted in 1995, the LMS was a terrestrially-based technology to provide location services.[138] The FCC held an auction for LMS licenses in 1998 and 1999 for three blocks of spectrum at 900 MHz.[139] The three blocks of spectrum coincided with a wide range of

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[134] One of the obligations of Part 15 devices is to accept interference. 47 C.F.R. §CFR 15.5(b).
[135] "Consumers May Experience Interference To Their Garage Door Opener Controls Near Military Bases," Public Notice, DA 05-424, 20 FCC Rcd. 3614 (Feb. 15, 2005), available at https://apps.fcc.gov/edocs_public/attachmatch/DA-05-424A1.pdf.
[136] *See* "Baby Monitor Buying Guide," Consumer Reports (, April 2016),, http://www.consumerreports.org/cro/baby-monitors/buying-guide.htm.
[137] 30 FCC Rcd. 387.
[138] *See* 47 C.F.R. §CFR 90.351 and following.
[139] The three blocks of spectrum are allocated for multilateration LMS:
(1) Block A 904.000-909.750 MHz and 927.750-928.000 MHz
(2) Block B 919.750-921.750 MHz and 927.500-927.750 MHz
(3) Block C 921.750-927.250 MHz and 927.250-927.500 MHz.

Part 15 unlicensed device uses including garage door openers and baby monitors as well as previously assigned applications under industrial, scientific, and medical ("ISM") applications.[140] After LMS licensees petitioned the FCC to reallocate the licensed spectrum for other purposes, the FCC launched an NPRM in 2006, but the rules were never altered.[141] Various licensees sought and received waivers of certain FCC rules, but the licensees had to demonstrate a lack of harmful interference with Part 15 devices.[142]

In addition to LMS, Part 15, and Part 18 devices, amateur radio service also have secondary status in the 900 MHz band. The conflicting uses by many types of transmitters have made it a difficult band for wireless operations, and many applications have migrated elsewhere.[143] Most new Part 15 devices appear to choose to operate at 2.4 GHz or 5 GHz where coordination through standards-setting bodies is better.

See "Location and Monitoring Service Spectrum Auction Scheduled for December 15, 1998," Public Notice, DA 98-1616, 13 FCC Rcd. 15,501 (Aug. 13, 1998), available at http://wireless.fcc.gov/auctions/21/releases/da981616.pdf. For further information on the auction, see Auction 21: Location and Monitoring Services (LMS), Federal Communications Commission, available at http://wireless.fcc.gov/auctions/default.htm?job=releases_auction&id=21..

[140] 47 C.F.R. §CFR 18.

[141] "Amendment of the Commission's Part 90 Rules in the 904-909.75 and 919.75-928 MHz Bands," WT Docket No. 06-49, Notice of Proposed Rulemaking, FCC 06-24, 21 FCC Rcd. 2809 (March 7, 2006).

[142] See FCC Docket 06-49.

[143] Unlicensed Spectrum Subcommittee Report, Commerce Spectrum Advisory Committee, National Telecommunications & Information Administration (January 6, 2010), available, at https://www.ntia.doc.gov/files/ntia/meetings/unlicensedspectrumsubcommitteereport_01102011.pdf ("This has meant that as some unlicensed bands (e.g., 900 MHz) have become increasingly congested with older, less spectrally efficient unlicensed devices, more advanced technologies have migrated to other bands, in the absence of incentives for legacy consumer uses to upgrade to more efficient, advanced technology.").

3. LTE-U and Wi-Fi

The FCC has a proceeding on interference between new LTE-U and LAA technology and their potential interference with existing Part 15 Wi-Fi devices and services operating in the same unlicensed bands.[144] The issue can be viewed partly as whether the FCC will protect existing services under a "priority in use" theory as it has in other proceedings. Laudably, the FCC did not impose a regulatory solution here, but rather urged parties to return to private standards setting as a way of avoiding regulation.

4. Blocking Wi-Fi

Although not the norm, some institutions have attempted to block access on their premises to non-sponsored Wi-Fi hotspots, including on a customer's cellular phone. In the past year, the FCC has taken several enforcement actions against such entities harmfully interfering with Wi-Fi service.[145] These FCC proceedings raised a conceptually intriguing issue about whether access to Wi-Fi is a right associated with an individual or with real property. The FCC determined that Section 333 of the Communications Act prohibits willful or malicious harmful interference to unlicensed as well as licensed signals. Thus, one can no more interfere with Wi-Fi than one can jam a cell phone—even on one's own property—despite Wi-Fi's unlicensed status.

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[144] "Office of Engineering and Technology and Wireless Telecommunications Bureau Seek Information on Current Trends in LTE-U and LAA Technology," ET Docket No. 15-105,. Pubic Notice, DA 15-516, 30 FCC Rcd. 4457 (May 5, 2015). As of February 1, 2016, the FCC had received more than 100 comments.
[145] *See supra*, n. 95.WiFi. FCC;;https://apps.fcc.gov/edocs_public/attachmatch/DOC-336102A1.pdf

5. The continuing problem of unresolved harmful interference disputes

The above list of harmful interference disputes is not exhaustive. Many disputes are not listed, and the number of disputes involving harmful interference to unlicensed spectrum is more likely to increase dramatically rather than recede. The list indicates that disputes involving interference can fester for years without resolution. To an economist, one of the simplest ways to resolve these and other disputes is to clarify the property rights concept of choice of use among the parties.

F. Privacy of usage

The earlier discussion of the refuge of a house as a man's castle in 17th and 18th century-England is also consistent with privacy. As long as the activities are lawful, what an individual does in the sanctity of the home is often considered a private matter.

Spectrum usage is different, and expectations of privacy of use—whether at the manufacturing, service provider, consumer, or enterprise customer level—are substantially diminished. Because it ultimately claims rights to all spectrum, the federal government also claims rights to monitoring how spectrum is used.[146] Service providers and third parties also often monitor wireless activity.

[146] See, e.g., "Quantitative Assessments of Spectrum Usage," National Telecommunications & Information Administration, U.S. Department of Commerce (November 2016), available, at https://www.ntia.doc.gov/files/ntia/publications/ntia_quant_assessment_report-no_appendices.pdf.

Ultimately, although spectrum in different bands is regulated in many different ways, from the perspective of service providers and consumers, choice of use across different types of regulated spectrum is remarkably similar.

VII. THERE IS LITTLE DIFFERENCE BETWEEN LICENSED AND OTHER SPECTRUM IN THE PROPERTY RIGHTS CONCEPT OF BENEFIT FROM USE

In this section, I examine the benefit from use of regulated spectrum for both service providers and for consumers and enterprise customers.[147] There is little difference in benefit from use between licensed spectrum and spectrum not subject to license.

In a 1980 New Hampshire Primary debate, Presidential candidate Ronald Reagan famously stated "I am paying for this microphone" to emphasize his right to speak and to benefit from the use of the microphone.[148] Reagan did not "own" the microphone, nor did he "own" any of the wires or spectrum that were used to connect the sound system, but he did have a conviction that he should have the benefit of the service of the microphone for which he had paid.

Most American consumers are oblivious as to whether their electronic devices use spectrum, much less whether that spectrum is licensed or not or some of each. Consumers simply expect their devices, for which they pay, to work and to benefit from the device.

[147] Manufacturers, service providers, consumers, and enterprise customers all have substantial benefit from use for unregulated spectrum.
[148] NHIOP, "Ronald Reagan: 'I Am Paying for this Microphone' 1980," YouTube (Jul. 22, 2013), https://www.youtube.com/watch?v=Rd_KaF3-Bcw.

From a manufacturer's perspective, there is little difference between manufacturing a device that needs licensed spectrum or spectrum without a license. All devices using spectrum need FCC approval to be sold in the United States. Licensed devices often need additional coordination with the licensee. From a consumer perspective, there is no difference at all.

Service providers can use either licensed spectrum or not, and service providers can be compensated for services offered with either licensed spectrum or not. There are no legal or regulatory limitations on benefitting from services offered using spectrum without licenses, as witnessed by the many commercial Wi-Fi service providers. If anything, users of licensed spectrum have the additional burden of paying annual licensing fees for such spectrum. Thus, licensed spectrum has a fixed cost for ownership that diminishes the benefit from use.

Ultimately, the property rights concept of benefit from use does not distinguish licensed from other forms of spectrum; all forms of spectrum have benefits from use.

VIII. LICENSED SPECTRUM HAS GREATER BENEFIT FROM TRANSACTIONS THAN OTHER FORMS OF SPECTRUM

In this section, I examine the benefits from the transactions of regulated spectrum for both service providers and for consumers and enterprise customers.[149] A common feature of most property is the ability to buy and sell it and to be able to benefit from that transaction. Commodities, land, securities, and other assets commonly considered property are commonly bought and sold. Thus, Coase, in his early writings on property rights in spectrum, focused on efficient assignment of spectrum rights through clarifying transactions rights and using auctions to transfer licenses from the public to the private sector. Coase noted the benefit from transactions to broadcast license holders.[150]

Today, consistent with the Coasian approach, rights to licensed spectrum are part of a market with many transactions and substantial valuations of the licensed spectrum rights. Substantial portfolios of licensed spectrum that can be used for such applications as mobile broadband can be worth tens of billions of dollars. Spectrum rights being transferred from the public to the private sector are auctioned,[151] and a vibrant secondary market allows buyers and sellers of spectrum rights to have contracts for exchange.[152] All of these transactions, however, are merely instrumental in enabling use of the underlying spectrum, without fully transferring *ownership* of the underlying spectrum. Relying on

[149] There is little if any benefit from transactions for most unregulated spectrum. One exception are air rights, which I do not address here.
[150] Coase, "The Federal Communications Commission."
[151] *See* Auctions Home Page, Federal Communications Commission, http://wireless.fcc.gov/auctions/default.htm?job=auctions_home.
[152] See, e.g., "Promoting Efficient Use of Spectrum through Elimination of Barriers to the Development of Secondary Markets," WT Docket No. 00-230, Third Report and Order, FCC 07-52, 22 FCC Rcd. 7209 (April 11, 2007), available, at https://apps.fcc.gov/edocs_public/attachmatch/FCC-07-52A1.pdf.

the 1927 Radio Act, the federal government retains its asserted ownership of the underlying spectrum and even of the licenses themselves. All that are transacted are the rights to use or control the licenses.

In contrast, one does not commonly speak of portfolios of rights to spectrum without licenses.[153] Spectrum without licenses is not subject to auction when transferred from the public to the private sector, and no secondary market is available for transactions of spectrum without licenses. But that is not the end of the story.

There are, of course, other market considerations in transactions involving assets that rely on spectrum without licenses. For example, consider two WISPs, both relying on unlicensed spectrum to access customers for Wi-Fi service, and both with identical equipment and identically no customers. A WISP that can potentially reach 5,000 customers is worth more than a WISP than can potentially reach only 1,000 customers, but the additional value is attributable to the geographic location, not the unlicensed spectrum itself.

In general, service providers, consumers, and enterprise customers are allowed to benefit from the sale of devices used for all types of spectrum. But, with the exception of licensed spectrum, transfers involving equipment do not correspond to transfers involving rights to spectrum.

[153] I do not address air rights in this paper.

Consequently, when considering just spectrum, we find that the first two property rights characteristics—(1) choice of use and (2) benefit from use—are widely present in both licensed spectrum and spectrum not subject to license. The third characteristic—(3) benefit from transactions—is largely present in just licensed spectrum.

IX. FOR THE REASONS ABOVE, THE VALUE OF APPLICATIONS FOR SPECTRUM WITHOUT LICENSE HAS GROWN RAPIDLY AND WILL LIKELY CONTINUE TO GROW RAPIDLY IF POLICY RECOMMENDATIONS ARE FOLLOWED

If we return to the initial question of whether the economic success of spectrum without licenses, and unlicensed spectrum in particular, is a refutation or a demonstration of the value of property rights concepts, the conclusion is that unlicensed spectrum is a demonstration of the value of property rights concepts. Empirically, unlicensed spectrum has been an economic success. It has been far more of an economic success since property rights for choice of use was assigned in 1989 more directly to service providers and customers than to the FCC.

This conclusion is entirely consistent with the widely known results of the property rights concepts associated with licensed spectrum. Since Coase, economists have widely recognized that increasing property rights concepts in licensed spectrum increases their value and economic activity. The economic logic is the same for spectrum without licenses.

Below, I present a few simple suggestions, drawing from theories of property rights, to improve the consideration of spectrum, particularly spectrum without licenses.

A. First, do no harm

The maxim for government consideration of spectrum including unlicensed spectrum should be "First, do no harm." Medicine should not have a monopoly on the Hippocratic Oath. Regulation should not harm the extraordinary value of the use of spectrum, including spectrum not subject to licensing. For example, clarification in 1989 of the right of providers, consumers, and enterprise customers to use unlicensed spectrum in the United States has created a whole new class of technologies, including Wi-Fi and Bluetooth, and created tremendous consumer good and economic value, all without the need for a burdensome regulatory structure. The United States does not want to kill the goose that laid the golden egg.

B. Recognize all forms of spectrum as having at least some elements of property rights

Second, it is past time to apply the powerful economic and legal framework of property rights to extract more value from all forms of spectrum, including spectrum not subject to licensing such as unlicensed spectrum. As explained above, property rights are rarely, if ever, absolute, and different combinations of these concepts may be more appropriate and valuable in some contexts than others. Service providers, consumers, and enterprise customers have substantial influence of choice of use of spectrum, including spectrum not subject to licensing, and benefitting from that spectrum use. Benefits from the transfer of spectrum rights are primarily for licensed spectrum. But some elements of

property rights can be found in all types of spectrum. In private discussions and in public forums, in government agencies and in businesses, among engineers and among lawyers, the concept of property rights in spectrum should be considered. Property rights concepts in spectrum cannot be advanced if they are never recognized, much less discussed.

Once we have begun to apply the proven conceptual framework of property rights to spectrum, we can further clarify and articulate those rights concepts. That is the admonition of Friedman. Property right concepts in spectrum, both licensed and other, need clarification. Clarifying property rights concepts in licensed spectrum would benefit property rights concepts in other forms of spectrum and vice versa.

C. Simplify federal spectrum regulation

Overregulation harms property rights concepts and harms the efficient use and innovation for spectrum, partially because it may disrupt patterns of rights that may otherwise have promoted efficient use. The period from 1934 to 1989 was a slow period for the development of unlicensed spectrum technologies. The reason, quite likely in large part, was that the FCC had extraordinarily burdensome regulatory requirements to use spectrum, and had not clarified the right to use spectrum on an unlicensed basis. Since, 1989, Part 15 devices have had substantial flexibility in use subject to standards-setting bodies.

Current regulations for spectrum are still more complicated than they need to be. For example, Part 15 devices, at more than 100 pages in length, could still be simplified. These rules currently are for devices ranging from “home-built devices” to “broadband

over powerlines" and apply to spectrum ranging from 160 kHz to 95 GHz. Although far better than the rules that preceded them, current Part 15 rules could be simplified to the likely benefit of all.

D. Rely more on IEEE and other standards-settings bodies

IEEE and other standards-setting bodies have been a great success by facilitating the flexibility of use of spectrum. Rather than have the FCC review and approve every change of use in multi-year review processes, the standards-setting bodies allow for much greater flexibility of use. The concept could be expanded to other types of spectrum including licensed spectrum.

E. Develop expedited dispute resolution procedures

Disputes at the FCC often take years to resolve, if ever. Even if the dispute were between the interests of buggy whips and horseshoes, the welfare losses from delayed resolutions are substantial. How much more substantial are the economic losses to society when the disputes are between interests involved in rapidly changing technologies such as those surrounding the use of spectrum.