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Radio Spectrum and the Disruptive Clarity of Ronald Coase

RADIO SPECTRUM AND THE DISRUPTIVE CLARITY OF RONALD COASE[1]

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In the *Federal Communications Commission*,[5] Ronald Coase exposed deep foundations via normative argument buttressed by astute historical observation. The government controlled scarce frequencies, issuing sharply limited use rights. Spillovers were said to be otherwise endemic. Coase saw that Government limited conflicts by restricting uses; property owners perform an analogous function via the "price system." The government solution was inefficient unless the net benefits of the alternative property regime were lower. Coase augured that the price system would outperform. His spectrum auction proposal was mocked by communications policy experts, opposed by industry interests, and ridiculed by policy makers. Hence, it took until July 25, 1994 for FCC license sales to commence. Today, some 73 U.S. auctions have been held, 27,484 licenses sold, and $52.6 billion paid. The reform is a textbook example of economic policy success. Herein, we examine Coase's seminal 1959 paper on two levels. First, we note its analytical symmetry, comparing administrative to market mechanisms under the assumption of positive transaction costs. This fundamental insight had its beginning in Coase's acclaimed article on the firm,[6] and continued with his subsequent treatment of social cost.[7] Second, we investigate why spectrum policies have stopped well short of the property rights regime that Coase advocated, considering rent-seeking dynamics and the emergence of new theories challenging Coase's property framework. One conclusion is easily rendered: competitive bidding is now the default tool in wireless license awards. By rule of thumb, about $17 billion in U.S. welfare losses have been averted. Not bad for the first 50 years of this, or any, Article appearing in Volume II of the *Journal of Law & Economics.*

JEL Categories: B31, D62, K11, K23, L51, L96, P14

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[5] R. H. Coase, R. H. Coase, *The Federal Communications Commission*, 2 J LAW & ECON 1 (1959).

[6] R. H. Coase, *The Nature of the Firm*, 16 ECONOMICA 386 (1937).

[7] R. H. Coase, *The Problem of Social Cost,* 3 J LAW & ECON 1 (1960).

I. INTRODUCTION

Ronald Coase postulates that an economist who "is able to postpone by a week a government program which wastes $100 million a year (what I consider a modest success) has, by his action, earned his salary for the whole of his life."[8] By symmetry, this standard applies when research brings a good law sooner. On that basis, Ronald Coase's single paper, *The Federal Communications Commission* ("FCC"),[9] has created such a bountiful account balance as to safely capitalize the Economists' Bank of Karma for generations to come.

The FCC paper was written in the spirit of Adam Smith's WEALTH OF NATIONS. In arguing a public policy position, Coase brought fundamentally new insights – *disruptive clarities* -- to system dynamics. His meticulous reasoning was delivered in two healthy portions. The first walked the reader through the argument for government planning as a solution to the so-called externality problem, "externality" being a term not used by Coase in either the FCC paper or the 1960 "Social Cost" paper to follow.[10] By focusing, rather, on how "harmful effects" were rationally evaluated in economic markets, the generality of the spillover problem was revealed. Social costs (externalities) were not exceptional cases and central planning was not a zero-cost default.[11] Governments and markets provide alternative forms of resource coordination; determining the socially efficient mix requires symmetric appraisals. To posit government taxes or controls as the costless default solution invokes the Nirvana Fallacy.[12]

The second source of disruptive clarity consisted of Coase's deconstruction of the government's logic to assign property rights by fiat. Regulators and the U.S. Supreme Court had confused the resource allocation question – *how airwaves were to be used* – with the rights ownership question – *who got to use them*. Licenses were assigned by comparative hearings

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[8] Ronald H. Coase, *Economists and Public Policy*, in J. Fred Weston, ed., LARGE CORPORATIONS IN A CHANGING SOCIETY (New York: NYU Press; 1975).

[9] R. H. Coase, *The Federal Communications Commission*, 2 J LAW & ECON 1 (1959).

[10] R. H. Coase, *The Problem of Social Cost*, 3 J LAW & ECON 1 (1960). Coase explicitly avoided "externality" in his attempt to show the generality of the resource allocation problem, breaking loose from the Pigouvian paradigm that characterized products with spillovers as uniquely leading to market failure. He thereby focused on alternative solutions to the resource problem, their costs, benefits and the government's facilitative role in defining flexible spectrum rights whose particular utilization could be valued and revalued in response to changing market and technological developments. Pigouvian static externality and its subsequent mathematical treatment consistently failed to motivate problem-solving processes that could answer the question of how and why government could implement regulations (or taxes) that would be efficient where markets failed. See Ronald H. Coase, THE FIRM, THE MARKET, AND THE LAW (Chicago: Univ. of Chicago Press; 1988); Carl Dahlman, *The Problem of Externality*, 23 J LAW & ECON 141 (April 1980).

[11] Coase was keen to note such asymmetries in the economics literature. The object of his critique in the 1959 FCC paper and then in his 1960, *The Problem of Social Cost*, 3 J LAW & ECON 1 (1960) was A.C. Pigou's influential THE ECONOMICS OF WELFARE (1920). Coase's *The Marginal Controversy*, 13 ECONOMICA 169 (Aug. 1946), found a similar 'zero cost for government policy' assumption embedded in the work of Harold Hotelling, *Stability in Competition*, 39 ECON J 41 (1929). Hotelling led many economists, including Abba Lerner and Paul Samuelson, to postulate that declining average cost goods were efficiently produced under a regime extending subsidies to suppliers who could thereby recover fixed costs while pricing outputs at marginal cost. Coase noted that the approach implied that the required information for classifying products (and technologies used to produce them) was freely available to the government, and that such subsidies (and the taxes required to fund them) would not distort market feedback loops revealing which projects to fund.

[12] Harold Demsetz, *Information and Efficiency: Another Viewpoint*, 12 J LAW & ECON 1 (April 1969).

("beauty contests") on the grounds that chaos would reign in the airwaves were the rights sold like other economic goods. Coase, observing licenses traded in secondary markets, saw the creation of resource use rights and the assignment of said rights as separable.

Both lines of thought, institutional symmetry and the allocation-wealth dichotomy, would figure prominently in Coase's seminal 1960 analysis, generally considered the most frequently cited research paper in the history of economics.[13] Here we ponder issues more specifically related to Coase's work on radio spectrum, organized by the two general strands delineated. In the first we evaluate spectrum policies under a positive transaction costs framework[14] helping to clarify recent critiques of Coase's property rights policy proposal as either (a) difficult to implement, given the stochastic nature of radio signals, or (b) obsolete, by virtue of newer digital radio technologies that permit the use of smart wireless devices in "spectrum commons." Both attacks embed the Pigouvian asymmetry that the Coasean analysis exposed.

In this paper, however, we focus largely on the widely adopted policy reform promoted in the Coase paper of 1959: wireless license auctions. When offered, the suggestion was treated with extreme hostility. Regulators, policy makers, industry officials, and academic experts were of the opinion that Coase was ignorant of the technical characteristics of radio spectrum and incorrect as to his allegedly radical economic analysis. Auctions would not only be bad policy, they would be impossible: airwaves were not susceptible to definition as property.

Coase's responses were sound, yet we need not rehash them. Over 30 other countries have run the experiment. On July 25, 1994, e.g., the Federal Communications Commission commenced Auction No. 1, selling ten Narrowband Personal Communications Services (N-PCS) licenses used for paging services. Aggregate winning bids of $617 million were generated. While N-PCS failed to prove profitable,[15] the government captured significant revenues and moved to hold additional auctions. In March 1995, 99 broadband personal communications services licenses (PCS) offering rights enabling competition with cellular operators were sold for $7 billion. Through 2008, 73 FCC auctions were held, 27,484 wireless licenses sold, and $52.6 billion collected from winning bidders.[16] See Appendix 1.

Auctions are now a well-established license assignment tool. "[S]pectrum auctions in the US have been a great success,"[17] a viewpoint widely shared by economists.[18] Policy makers have been energetic in claiming credit for their implementation. Indeed, wireless auctions now constitute a textbook example of efficient regulatory reform. That Coase persevered in his analytical enterprise when his work was questioned by all about him, is a tribute to his character, the quality of his thought, and the substance of the economic model on which he built.

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[13] Thomas W. Hazlett, *Ronald H. Coase*, Chapter 1 in L. Cohen & J. Wright, eds. PIONEERS IN LAW AND ECONOMICS 1 (Cheltenham, U.K.: Edward Elgar; 2009), p. 1.

[14] See Coase Theorem discussion below.

[15] Paging services had been profitable, but were about to be displaced by cellular services. James B. Murray, Jr. WIRELESS NATION (2001).

[16] *Statement by FCC Chairman Kevin J. Martin*, News Release, Federal Communications Commission (March 18, 2009) and FCC website. For a summary of FCC reported auction results, see Appendix 1.

[17] Mark Scanlan, *Hiccups in US Spectrum Auctions*, 25 TELECOMMUNICATIONS POLICY 689 (2001), 690.

[18] See, e.g., Paul Milgrom, PUTTING AUCTION THEORY TO WORK (2004).

Coase (1959) is far less famous a work than its elaboration in Coase (1960). That paper was published pursuant to an invitation for a correction from JLE editors, who claimed that it erred in its treatment of externalities. But the editors of this JOURNAL were wrong; the *Federal Communications Commission* paper did not commit a "very interesting error"[19] but offered a lucid correction. We focus on two aspects of that analysis here:

(1) *Symmetric evaluation of resource appropriation rules*. Coase thought clearly about the economics of damaging spillovers: they were byproducts of valuable activities and, as such, were productive inputs subject to the same cost-benefit calculus as other resources. This understanding led Coase to view legal rules not as palliatives for market failures, but as mechanisms to discover trade-offs and achieve optimal outcomes. As soon as this task is made clear, and the complex nature of the changing opportunities realized, it is apparent that a government-managed process is simply one alternative, while markets form the standard default in a modern economy. The role of economic analysis was not to assume away the problem by the *deus ex machina* of no-cost public regulation, but to compare institutional options, apples-to-apples. This common sense was uncommon, and it exposed the theoretical weakness of an economic paradigm that proved market failure while assuming perfect governments.

(2) *The public policy of auctioning radio frequency ownership rights.* This signature policy payoff of Coase's 1959 paper begs the query: what other scholarly article has helped trigger such enormous real-world changes? Competitive bidding for wireless license awards, a reform uniformly traced to Coase (1959), began in New Zealand in 1989, in the U.S. in 1994, and is now employed in dozens of countries. License assignments have proceeded as suggested, eliminating costly delays and inefficiencies. Yet license auctions do not enable market allocation of radio spectrum, and may in fact exacerbate the artificial scarcity imposed by regulation. U.S. policy has, in recent years, been stymied by policy retrogression, under-allocating bandwidth for mobile networks and rejecting liberal licenses in favor of "re-regulation." Some of the problem can be traced to Coase's "bundle of rights" property agnosticism (addressed previously by Thomas Merrill and Henry Smith[20]), which now calls for amendment. We modestly propose a Coase (1959) 2.0 Edition that incorporates fifty years of wireless market experience to extend the efficiencies of license auctions to spectrum markets.

Coasean Disruption may be just getting started.

II. TWO SYMMETRIES AND ONE EMPIRICALLY TESTABLE PRESUMPTION

Coase (1959) brought clarity to resource economics by exposing two asymmetries in the existing analysis, and then tucking these insights into the comfortable paradigm of Adam Smith's "invisible hand." First, he revealed that cost "externalities" were not special cases but standard economic inputs (or outputs). The social goal is not to eliminate (maximize) them but to

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[19] Coase (1993), p. 250.

[20] Thomas W. Merrill and Henry E. Smith, *What Happened to Property in Law and Economics?* 111 YALE L J 357 (Nov. 2001).

maximize economic value.[21] Second, the challenges encountered in doing so were not, uniquely, market failures. They were real-world problems confronted by government regulators or private owners. To assert that markets broke down when they failed to optimally deploy resources was unhelpful; it said nothing about the relative success of some alternative set of rules. Direct government regulation, tax/subsidy schemes, and private property rights – including the many variants of each – were to be empirically evaluated to determine the best methods for maximizing net social output. Third, Coase was not agnostic about where the analysis would trend. Coase anticipated that full, fair, well-informed evaluations would find that decentralized resource owners generally outperformed state *diktat*.

These insights profoundly influenced development of both theory and empirical research. Yet, we note that much of the essential wisdom has yet to permeate ongoing economic discussion, particularly in the policy realm in which the Coasean analysis began – radio spectrum allocation. We address each of these contributions in this light.

a. *Opportunity Costs of Reducing "Harmful Effects"*

The U.S. Supreme Court argued in 1943 that, because "there is a fixed natural limitation upon the number of stations that can operate without interfering with one another,"[22] the government was virtually forced to tightly control spectrum use. Without such central administration, endemic interference between stations would produce chaos, what a later Court would dub "a cacophony of competing voices."[23]

Coase confronted the Supreme Court's "misunderstanding of the nature of the problem,"[24] and made a remarkable discovery. First, the limited nature of frequencies simply suggested a scarcity constraint. Countless other scarce resources were efficiently allocated by "the price system."[25] Second, whatever spectrum use rights were assigned to wireless users could be assigned by auctions rather than fiat. This was an idea proposed initially by University of Chicago Law student Leo Herzel in 1951, who suggested this approach not after studying under Milton Friedman or Aaron Director, but having read Abba Lerner's THE ECONOMICS OF CONTROL (1944).[26] He was a good student: selling rights to the highest bidder was a logical way for a socialist system to theoretically rationalize distribution. While then controversial, the proposition cannot be in dispute: today the FCC does precisely this.[27]

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[21] It should be noted that A.C. Pigou's ECONOMICS OF WELFARE (1920) did not seek to categorically suppress spillovers, but to incrementally tax or subsidize allocation choices so as to force decision makers to rationally account for them. But where Pigou saw certain types of markets as subject to special policy interventions due to "externalities," Coase brought clarity by showing how the allocation of "harmful effects" (or "beneficial effects") was just another resource use question.

[22] *National Broadcasting Co. v. United States*, 219 U.S. 190 (1943), p. 213.

[23] *Red Lion v. FCC*, 395 U.S. 367 (1969).

[24] Coase (1959), p. 14.

[25] "Land, labor and capital are all scarce, but this, of itself, does not call for government regulation." Coase (1959), p. 14.

[26] Ronald H. Coase, *Law and Economics at Chicago*, 36 J LAW & ECON 239 (April 1993). See also, Leo Herzel, *"Public Interest" and the Market in Color Television Regulation*, 18 U CHIC L R 802 (1951).

[27] The alert reader will note that the issue should not have been in dispute in 1959, either, as radio and television stations traded freely in the marketplace – licenses and all. But such transactions did not appear to settle the matter, as witnessed by the experts' consensus denouncing the suggestion as hopelessly naïve.

Coase's third argument went much further. The government mitigated conflicts between users by sharply limiting resource use – a regime that "relies exclusively on regulation and in which private property and the pricing system play no part"[28] – but could potentially achieve the same objective far more efficiently. However it initially defined resource use rights, it could allow users to recontract. Rights holders would then generate gains from trade, reducing interference when neighboring frequency users paid them more than they gave up, either accepting higher levels of airwave congestion or using mitigation techniques of their own – improved technology, adjusted operations, or relocation. In this manner, users would act like property owners, searching for ways to increase the value of their assets.

> One of the purposes of the legal system is to establish that clear delimitation of rights on the basis of which the transfer and recombination of rights can take place through the market. In the case of radio, it should be possible for someone who is granted the use of a frequency to arrange to share it with someone else, with whatever adjustments to hours of operation, power, location and kind of transmitter, etc., as may be mutually agreed upon; or when the right initially acquired is the shared use of a frequency (and in certain cases the FCC has permitted only shared usage), it should not be made impossible for one user to buy out the rights of the other users so as to obtain an exclusive usage.[29]

This angle led Coase to see that the "externalities" were resource use conflicts entirely analogous to the input costs that firms routinely incurred in producing valuable goods and services. When clearly owned, they were rationally allocated. What made them seem to be of a special character were circumstances making private ownership ill-defined.[30] But those circumstances were not automatically eliminated by state ownership, government regulation, or a tax and subsidy scheme. Such approaches were just another way to deal with the same conflicts over alternative resource use. The confusion was apparent in radio spectrum, where private ownership was said to be impossible – but where regulators allegedly averted potential chaos by issuing rules excluding most resource uses so that they could award protected, unobstructed use rights to lucky licensees.

Coase saw that such rights could be more efficiently and transparently distributed by auction. But that was a very limited reform, because "the enforcement of such detailed regulations for the operation of stations as are now imposed by the Federal Communications Commission would severely limit the extent to which the way the frequency was used could be determined by the forces of the market."[31] If emission rights were broadened to constitute ownership of frequencies, then private owners could deploy new technologies, services, and business models, make deals across FCC-defined borders, adjust to changing circumstances, and remix combinations of factors – including spectral inputs -- to discover the optimal level of interference. In a dynamically changing world, such efficiencies would be continually updated.

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[28] Coase (1959), p. 34.
[29] Coase (1959), p. 25.
[30] Owners have, most essentially, the right to exclude others from appropriating their property. When lines cannot be drawn to delineate borders, the effort to define rights suffers.
[31] Coase (1959), p. 25.

Such owners would not eliminate spillovers but be motivated to discover the efficient levels and types. Some owners would buy neighboring (or distant) rights to emit, others sell, all comparing costs to benefits in order to maximize the value of their slices. The result would be a complex balancing. This was starkly at odds with the prevailing view that "harmful interference" was destructive and would be endemic without pervasive regulatory management of radio use. "It is sometimes implied that the aim of regulation in the radio industry should be to minimize interference. But this would be wrong. The aim should be to maximize output."[32]

Over time, spectrum ownership rights for certain types of licenses did expand, coming to resemble private ownership of the bandwidth allocated to the FCC license. For mobile wireless services, in particular, spectrum authorities in the U.S. and elsewhere have granted liberal rights that delegate the choice of technologies, services, and business models largely to the licensee. This regulatory reform has generated enormous value in assisting the efficient organization of markets.[33] The problem is that it has been parsimoniously applied, allotting relatively little spectrum to liberal licenses, and continuing the use of the state property regime for allocations. This provokes new challenges for economic policy, as discussed below.

b. *Institutional Symmetry, and the Incredible Lightness of Stigler's "Coase Theorem"*

What has come to be called the Coase Theorem, courtesy of George Stigler,[34] obscures the Coasean analyses of 1959 and 1960 and leads to hazardous analytical detours.[35] The Stiglerian version is that, with zero transaction costs, resources will be efficiently deployed no matter which party is endowed with ownership rights. This discussion, with these conditions, appears in Coase (1960) not as a "theorem" but to critique the existing economic theory that assumed away information and transactions cost when actions were taken by the state. Coase, noting that the assumptions employed produced no market (or non-market) failure, then focused on situations with positive transaction costs as the real analytical challenge. Efficient liability rules would be found by comparing the more effective organizational rules when all costs were included.

The confusion about Coase's alleged reliance on the zero transaction cost assumption obscures his central message, a diversion of enormous consequence. Such a default position is easily toppled. The case for Pigouvian taxes or state property ownership is reconstituted via demonstration of "transaction costs." When evidence establishes this real world commonplace, the case for market failure is made. The analysis shifts to consider what form of government intervention is best employed to salvage the situation.

This does great violence to Coase's analysis on multiple levels. First, it implicitly takes "transaction costs" as a fixed feature of markets, exogenous from the legal rules or regulations

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[32] Coase (1959), p. 27.

[33] Thomas W. Hazlett, *Optimal Abolition of FCC Allocation of Radio Spectrum*, 22 J ECON PERSP 103 (W 2008a).

[34] "This proposition, that when there are no transaction costs the assignments of legal rights have no effect on the allocation of resources among economic enterprises… I christened… the Coase Theorem." George J. Stigler, MEMOIRS OF AN UNREGULATED ECONOMIST (Chicago: University of Chicago Press; 1988), p. 77.

[35] This conclusion has been rendered by Ronald Coase (1988) himself.

imposed by the state.[36] This is clearly incorrect; the way property rights are defined has great bearing on how such rights can be productively used in the marketplace.[37] Second, when rights are defined and distributed by the state in ways that hamper efficiency, the resulting "tragedy" is properly a *non*-market failure. By refusing to undertake transactions that are, given their cost, not worth the benefits sought, private property owners make efficient choices.[38] What needs to be fixed is the legal structure.

Third, Coase (1959) is crystal clear in its focus on symmetric comparison of the (positive) transactions costs faced by government in parceling out limited use rights for wireless applications, on the one hand, and an alternative system in which private entities owned the frequencies. Either set of decision makers (regulators v. owners) would have to make choices about the various ways the airwaves could be used, determining the cost of more emissions in one enterprise against the restricted opportunities (due to greater "interference") for others. Coase saw that the "price system" was not free to set up or operate, and neither was it costless to constrain potential wireless users with government restrictions. Costs were incurred when some potentially valuable activities were barred due to a lack of authorization. Further, he saw that while technical parameters helped determine the options the resource allocators faced, the alternatives they selected were economic choices with costs and benefits. These were brushed aside by policy experts claiming that the nature of radio waves made markets irrelevant.

Coase saw, for example, that the allocation of a given block of frequencies for television broadcasting, to the exclusion of other wireless services, was not pre-determined by engineering rules.[39] It was a choice made by regulators that reflected their belief that the value obtained from this use of bandwidth exceeded the value of the excluded opportunities. There were other ways to perform the same coordination. They might render superior efficiencies.

In short, the technological facts did not dictate that government control resource allocation. It was not sufficient to merely posit a market failure to establish a case for administrative allocation. One had to consider the operational effectiveness of one system against the alternatives. As sensible as the conclusion was, it was radical at the time. An FCC

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[36] "The exclusive use model should be applied primarily but not exclusively in bands where scarcity is relatively high and transaction costs associated with market-based negotiation of access rights are relatively low. The commons model should be applied primarily but not exclusively in bands where scarcity is relatively low and transaction costs are relatively high." Federal Communications Commission, *Spectrum Policy Task Force Report* (Nov. 15, 2002), p. 5. We note the FCC's confused terminology, referring to the private property model as "exclusive use," when such bandwidth constitutes the most intensively shared frequency spaces in economic terms, and to unlicensed bands as "commons," when such frequencies are regulated by governance rules imposed by the FCC under administrative allocation.

[37] For instance, a tragedy of the anti-commons ensues when rights are defined in fragmented, overlapping contours that are prohibitively costly to reassemble. See Michael Heller, THE GRIDLOCK ECONOMY (2008).

[38] Harold Demsetz, *Ownership and the Externality Problem*, in T. Anderson & F. McChesney, PROPERTY RIGHTS: COOPERATION, CONFLICT, AND LAW (Princeton, NJ: Princeton University Press; 2003).

[39] "[I]t is not clear why we should have to rely on the Federal Communications Commission rather than the ordinary pricing mechanism to decide whether a particular frequency should be used by the police, or for a radiotelephone, or for a taxi service, or for an oil company for geophysical exploration, or by a motion-picture company to keep in touch with its film stars or for a broadcasting station. Indeed, the multiplicity of these varied uses would suggest that the advantages to be derived from relying on the pricing mechanism would be especially great in this case." Coase (1959), p. 16.

Chief Economist, Dallas Smythe, represented the prevailing view, dismissing market allocation as imperfect and therefore irrelevant. Coase responded:

> Professor Smythe also argued that the use of market controls depends on 'the economic assumption that there is substantially perfect competition in the electronics field.' This is a somewhat extreme view. An allocation scheme costs something to administer, will itself lead to a misallocation of resources, and may encourage some monopolistic tendencies – all of which might well make us willing to tolerate a considerable amount of imperfect competition before substituting an allocation scheme for market controls.[40]

Coase explained that there is no such thing as a free allocation system. The efficient social choice considered the disparate options, symmetrically. That is not a result of the zero transaction cost assumption, but its opposite.

c. The Market Efficiency Default

While Coase went "looking for results,"[41] he was not agnostic. He analyzed radio spectrum in 1959 as Adam Smith had analyzed commodity markets in 1776. The "invisible hand" had much to offer. A CBS broadcast executive expressed surprise when asked at a 1958 congressional hearing about the possibility that the "avenues of the air" should be sold by the Government such that "the taxpayer would be getting the proceeds."[42] Coase delights in quoting the broadcaster's response, "[t]his is a new and novel concept,"[43] offering the retort: "This 'novel theory' (novel with Adam Smith) is, of course, that the allocation of resources should be determined by the forces of the market rather than as a result of government decisions."[44] He then further reveals his empirical priors:

> Quite apart from the malallocations which are the result of political pressures, an administrative agency which attempts to perform the function normally carried out by the pricing mechanism operates under two handicaps. First of all, it lacks the precise monetary measure of benefit and cost provided by the market. Second, it cannot, by the nature of things, be in possession of all the relevant information possessed by the managers of every business which uses or might use radio frequencies, to say nothing of the preferences of consumers for the various goods and services in the production of which radio frequencies could be used. In fact, lengthy investigations are required to uncover part of this information, and decisions of the Federal Communications Commission emerge only after long delays, often extending to years. To simplify the task, the Federal Communications Commission adopts arbitrary rules.[45]

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[40] Coase (1959), p. 16.
[41] Interview with Thomas W. Hazlett, REASON (Jan. 1997).
[42] Coase (1959), p. 17.
[43] Ibid.
[44] Coase (1959), p. 18.
[45] Ibid

Having eliminated confusion as to "technical issues" and "externalities," Coase demonstrated that FCC planning mechanisms did not import special skills or avoid critical trade-offs. Rather, the agency was unlikely to exhibit comparative advantage in allocating bandwidth. Competitive markets would reveal opportunity costs and reward entrepreneurial efforts to identify potential benefits from innovation, improving social coordination. In this, Coase operated mainly from theory, not from his own detailed examination of alternative regulatory models. With the liberalization of certain important wireless licenses over the past half-century, however, the evidence is overwhelming: the normative recommendation was correct.[46] Coase's priors proved a testament to his ability to apply economics to markets and to the power of his theoretical model.

d. *The Contemporary Radio Spectrum Policy Debate Lags Coase (1959)*

Two recent objections to private property rights in spectrum are noteworthy. The first is that such rights are sufficiently difficult to define that a premature shift to spectrum markets may be worse than the inefficiencies inflicted by administrative allocation. The second is that the exclusive ownership rights presumed efficient by Coase may, given advanced wireless technologies, no longer be socially useful. Today's smart radios can steer their way around "harmful interference" through computational power, such that the coordination of property rights is unhelpful and the overhead associated with ownership wasteful. In forcing transactions between rights holders, it imposes the costs of the price system when more productive alternatives – such as "spectrum commons" – are available.

Both assertions fail to embed the symmetry of the Coasean analysis. When that is restored, and marketplace evidence appropriately weighed, either argument collapses. We discuss each in turn.

i. *Private property rights are difficult to define.*

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[46] Evan R. Kwerel & John R. Williams, *Changing Channels: Voluntary Reallocation of UHF Television Spectrum*, FCC Office of Strategic Planning & Policy Analysis Working Paper No. 27 (Nov. 1992); Gregory L. & Jeffrey S. Steinberg, *Using Market-Based Spectrum Policy to Promote the Public Interest*, 50 FED COMM L J 1 (Dec. 1997); Pablo T. Spiller & Carlo Cardilli, *Towards a Property Rights Approach to Communications Spectrum*, 16 YALE J REG 53 (1999); Lawrence J. White, *"Propertyzing" the Electromagnetic Spectrum: Why It's Important, & How to Begin*, 9 MEDIA LAW & POLICY 19 (2000); Bruce M. Owen & Gregory L. Rosston, *Spectrum Allocation and the Internet*, Chapter 10 in W.H. Lehr and L.M. Pupillo, eds., INTERNET POLICY AND ECONOMICS 151 (Springer; 2001); Thomas W. Hazlett, *The Wireless Craze, the Unlimited Bandwidth Myth, the Spectrum Auction Faux Pas, and the Punchline to Ronald Coase's 'Big Joke': An Essay on Airwave Allocation Policy*, 15 HARV J L & TECH 335 (Spring 2001); Martin Cave, Review of Radio Spectrum Management by Professor Martin Cave for Department of Trade and Industry for Her Majesty's Treasury (March 2002); Evan R. Kwerel & John R. Williams, *A Proposal for a Rapid Transition to Market Allocation of Radio Spectrum*, FCC Office of Strategic Planning & Analysis Working Paper No. 38 (Nov. 2002); Gerald R. Faulhaber & David J. Farber, *Spectrum Management: Property Rights, Markets, and The Commons*, AEI-Brookings Joint Center for Regulatory Studies Working Paper No. 02-12 (Dec. 2002); Thomas W. Hazlett & Matthew L. Sptizer, *Advanced Wireless Technologies and Public Policy*, 79 SO CAL L R 595 (March 2006); Gerald R. Faulhaber, *The Future of Wireless Communications: Spectrum as a Critical Resource*, 18 INFO ECON & POL'Y 256 (Sept. 2006); Martin Cave, Chris Doyle & William Webb, ESSENTIALS OF MODERN SPECTRUM MANAGEMENT (Cambridge Univ. Press; 2007); Thomas W. Hazlett, Giancarlo Ibarguen, & Wayne Leighton, *Property Rights to Radio Spectrum in Guatemala and El Salvador: An Experiment in Liberalization*, 3 REV L & ECON 437 (Dec. 2007); Hazlett (2008a).

Phil Weiser and Dale Hatfield write:

> Numerous commentators have built on Coase's wisdom and charted paths to facilitate markets in spectrum. However, defining rights to use spectrum is far more difficult than ordinarily suggested. Problems such as geographic spillover and adjacent channel spillover make it much more difficult to define rights to spectrum and to determine how to measure when those rights have been transgressed. Unlike the case of real property, which is measured in two or three dimensions, there are as many as seven dimensions by which electromagnetic frequency can be measured, and the best way to measure these dimensions remains unsettled. Many decisions remain, such as whether to use statistical models of radio wave propagation, actual measurement of interference, or some combination of the two to determine the scope of rights in spectrum.[47]

The complexity of predicting the path of radio emissions, and then their ownership, is then said to present a problem for policies promoting spectrum markets. But the question is not whether resource ownership is more difficult to define than with, say, real property, but whether competitive markets can out-perform government regulators in the cost-information discovery task central to allocating *radio spectrum* resources. The complexities of spectrum relative to other forms of property are not the issue.[48] If that unique complexity is well stated (it is unlikely to be, given that the many complications of real property law, not to mention those of legal regimes for water, space, the sea, fisheries, underground oil reserves, or intellectual property), then it is equally an issue for all. Yet, "the difficult policy choices ahead" in spectrum are categorically focused on the costs of private property rights. Fortuitously, this approach is rejected in the property rights literature Coase triggered.[49]

Property rules are always tailored to circumstances. If it is true that "[a] property rights system that relies heavily on ex ante predictions rather than ex post findings of actual interference would, involve several sacrifices,"[50] and those sacrifices are more costly than the alternative, the implication is that the legal rules should be light on ex ante definitions and rely more on ex post adjudication.[51] The implicit presumption that private property rules cannot achieve this efficient turn is to attack a straw man. And, again, the question is whether the state property regime will do better.

Coase, Meckling & Minasian specifically addressed the uncertain boundaries of spectrum property rights in their long suppressed Rand study (written in 1962), which served as the

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[47] Dale Hatfield & Phil Weiser, *Toward Property Rights in Spectrum: The Difficult Policy Choices Ahead*, Cato Policy Analysis 575 (Aug. 17, 2006).

[48] But were they, the assertion made would not end the query. Property rights to land are plainly not fully defined in just two or three dimensions. Questions about ownership of airspace rights (including airplane flyover use), encroachments of sky views by neighboring buildings, sub-surface mineral rights, adverse possession, liability and spillover rules suggest far more complexity.

[49] For a summary of this literature, see Dean Lueck & Thomas J. Miceli, *Property Rights and Property Law*, in M. Polinsky and S. Shavell, eds., HANDBOOK OF LAW AND ECONOMICS (2007).

[50] Hatfield & Weiser (2006), p. 16.

[51] This bears a striking resemblance to the path followed in intellectual property law where, e.g., patents are only clearly defined when litigated – as happens in those tiny minority of patents that prove to be (a) valuable, and (b) contentious.

empirical source of the argument that private property rights were (are) non-viable. "Those concerned with policy in this area seem to have assumed that the delimitation of property rights would be extremely difficult, if not impossible, and consequently that it was inconceivable that there could be a market in radio frequencies…"[52] This reflected a misunderstanding of property rights, which do not define things but the rights of economic agents to "do certain things."[53]

To help coordinate the productive use of resources, rules limit some activities in order to enhance others. Vesting a broadcast station with the exclusive right to operate a television station at a particular location at a fixed power level for specified hours to be supported only by advertisements (no subscription fees) under the administrative allocation regime is one way of doing that. But social costs are incurred to the degree that the services excluded by the regulations have value. Indeed, the FCC's parsimonious spectrum use rights left large (and growing) values foreclosed, addressing the problem of stochastic radio waves by leaving wide spaces between broadcast channels such that the vast majority of TV slots are today unoccupied – even after the analog TV turn-off some 83% of local TV channels host no broadcasts.[54] Regulators do not see these channels as wasted; it is how they control interference. It is, by consensus, a hugely expensive way to coordinate wireless services in the TV band,[55] airwaves that could generate over $1 trillion in net present value consumer welfare gains if the remaining TV stations were moved to more efficient (cable or satellite) delivery platforms.[56]

Hence, the stochastic nature of radio waves does not present a challenge to private property rights, but to *any* legal rights structure. "If radiation cannot in fact be confined geographically, neither the FCC nor any other government agency, nor a market system can make it confinable so long as it is emitted."[57] This contribution of Coase (1959) is not well integrated into today's discussion. To wit, Hatfield & Weiser write:

> Compounding the issues related to limits on signal strength, we also underscored that the actual signal strength at the geographic boundary can vary significantly. In particular, depending on the height of the receiving antenna as well as the time and location in the immediate area of the receiver (vis-à-vis their effects on radio propagation), results can vary widely. To emphasize this point, we analyzed the extreme but historically important case of AM radio. In so doing, we described the wide changes in signal strength due to diurnal, seasonal, solar cycle, and path location variations, concurring with [Charles] Jackson's conclusion that introducing a property-rights regime in the AM radio band along the lines used for real property

[52] Ronald Coase, William H. Meckling, and Jora Minasian, *Problems of Radio Frequency Allocation*, Rand DRU-1219-RC (Sept. 1995), p. 93.
[53] Ibid.
[54] There are 210 TV markets in the United States, and approximately 1,750 full-power television stations. With 49 TV channels allocated nationwide, there are 10,290 local channel slots. Just 17% host TV broadcasts.
[55] Hazlett 2008a; Phil Weiser, *The Untapped Promise of Wireless Spectrum*, Hamilton Project Discussion Paper, Brookings Institution (July 2008).
[56] Thomas W. Hazlett & Vernon L. Smith, *Don't Let Google Free the Airwaves*, WALL ST J (Oct. 3, 2008); and Thomas W. Hazlett, *The U.S. Digital TV Transition: Time to Toss the Negroponte Switch*, AEI-Brookings Joint Center for Regulatory Studies Working Paper No. 01-15 (Nov. 2001).
[57] Coase, Meckling & Minasian (1995), p. 136 (emphasis original).

would face enormous—and likely insurmountable—difficulties.[58]

But the "enormous…. difficulties" encountered when signals randomly skip through the atmosphere, cited as debilitating to market owners, equally constrain the choices made by regulators. FCC licensing policies characteristically over-protect against interference, allocate far too few AM broadcasting facilities,[59] deny licenses to entrants,[60] and block technological innovation that would increase market competitiveness.[61] Not only must these costs be considered in the choice of regime, so must the myriad legal options for crafting efficient private property rules.

Where the FCC has defined AM radio broadcasting rights, a property system can be enabled by loosening existing restrictions on the template already used in practice. Spectrum allocated to licenses would be the de jure or de facto property of the licensee, and rights holders would be able to exclude others from encroaching on the use of such resources according to precedents in place (in property law or regulatory rulings). Where needlessly expensive contentiousness is observed or reasonably anticipated, it may be mitigated with ex post adjudication devices that lower costs. This evolution of property rights is, indeed, how the liberal license model, analogous to private property in radio spectrum, has been adopted in most countries for mobile wireless services.[62] These exclusive ownership rights are used far more intensely, and attract far more investment in complementary network infrastructure, providing empirical support for Coase's priors.

ii. *Coase's property rights are obsolete in the digital era.*

The property rights approach to radio spectrum has been challenged in many law review articles over the past decade.[63] The argument for exclusive rights is characterized as an anachronism appropriate to an earlier day when radios were primitive and interference was acute. Now, with newer wireless devices, there is little need for rationing spectrum. Autonomous radio users can easily navigate through congested airspace; indeed, airwaves that were scarce resources requiring choices between alternative uses will now accommodate all.[64]

Citing the popular use of unlicensed bands hosting cordless phones, wi-fi modems, and other radio devices operated with non-exclusive use rights, such scholars argue that private spectrum property should be largely abandoned in favor of "spectrum commons." According to Yochai Benkler:

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[58] Hatfield & Weiser (2006), pp. 15-16. Citing to Charles L. Jackson, *Limits to Decentralization: The Example of AM Radio Broadcasting or Was a Common Law Solution to Chaos in the Radio Waves Reasonable in 1927?* Telecommunications Policy Research Conference (2005).

[59] Thomas W. Hazlett, *The Rationality of U.S. Regulation of the Broadcast Spectrum*, 33 J L & ECON 133 (April 1990).

[60] Thomas W. Hazlett & Bruno E. Viani, *Legislators vs. Regulators: Who Killed Low Power FM Radio?* 7 BUSINESS & POLITICS, No. 1 (April 2005).

[61] As in the suppression of FM radio and satellite radio. See Hazlett (2001).

[62] A small number of countries have adopted statutory reforms that have granted more explicit private property rights in spectrum. See discussion in Thomas W. Hazlett, *Property Rights and Wireless License Values*, 51 J L & ECON 563 (Aug. 2008).

[63] A good summary is given in Stuart Benjamin, *Spectrum Abundance and the Choice Between Private and Public Control*, 78 NYU L R 2007 (2003).

[64] Gregory Staple & Kevin Werbach, *The End of Spectrum Scarcity*, IEEE SPECTRUM (March 2004).

> It [is] now possible to change our approach, and instead of creating and enforcing a market in property rights in spectrum blocks, we could rely on a market in smart radio equipment that would allow people to communicate without *anyone* having to control "the spectrum"… This approach has been called a "spectrum commons" approach, because it regards bandwidth as a common resource that all equipment can call on, subject to sharing protocols, rather than as a controlled resource that is always under the control of someone, be it a property owner, a government agency, or both.[65]

Citing "evidence of a massive crack in the Coasian spectrum theory,"[66] another writer suggests that "it is not a stretch to propose that Coasian spectrum markets might be an outmoded relic of the era in which they were conceived."[67]

The argument proves uncompelling. In theory, the unlicensed bands are neither "open access" nor "spectrum commons" but government allocations, with rules imposed by regulators to mitigate conflicts. The rules embed a licensing scheme applied to equipment; no radio may be used unless authorized for unlicensed operation by the FCC. Approvals mandate power limits and technology restrictions. Rather than demonstrate the end of scarcity, the use of such bands clearly shows how rivalrous uses continue to contend for valuable bandwidth. Only by virtue of the government's restrictions are users of non-exclusive rights protected from tragedy of the commons. This method of allocating spectrum, however, exhibits the traditional infirmities of administrative allocation. Spectrum is set-aside for unlicensed use, and rules to govern access are crafted, under political choices that generally lack the relevant price data or profit incentives.

In practice, unlicensed allocations are not eclipsing liberal licensed bands, which dominate economic activity.[68] The providers of mobile services generate over $150 billion in consumer surplus annually,[69] overwhelming wireless applications supplied with unlicensed spectrum. Were unlicensed bands eclipsing exclusive spectrum rights as per the march of technology, carriers would save billions of dollars by shifting their mix of inputs to increasingly favor unlicensed bandwidth. The 2008 FCC auction of 700 MHz licenses generated $19 billion at the highest prices, adjusted for bandwidth, yet received by the government for mobile licenses.[70] More fundamentally, exclusive ownership rights support economic coordination, promote investments to create networks complementing airwaves and dramatically increasing their productivity. No other rights regime, whether for traditional licenses or unlicensed bandwidth, comes close to matching, let alone displacing, this value-generating result.

In short, there is no market migration away from private property rights. Indeed, the most binding regulatory constraint is the parsimonious allocation of liberally licensed bandwidth.

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[65] Yochai Benkler, *Some Economics of Wireless Communications*, 16 HARV J L & TECH 25 (Fall 2002), p. 28 (emphasis original; footnote omitted).

[66] Patrick S. Ryan, *Wireless Communications and Computing at a Crossroads: New Paradigms and their Impact on Theories Governing the Public's Right to Spectrum Access*, 3 J TELECOM & HIGH TECH L 239 (Spring 2005), pp. 259-60.

[67] Ibid., p. 260.

[68] Hazlett & Spitzer (2006).

[69] Hazlett (2008a).

[70] See Appendix 1.

Coase's 1959 analysis survives the digital era, continuing to prescribe the correct policy path: allow spectrum resources to be owned by responsible economic agents.[71]

III. THE INTELLECTUAL PIVOT FOR AUCTIONS

When Ronald Coase began his investigation of public policy for radio spectrum, communications policy experts in the U.S. widely held that radio spectrum rights were optimally held by the state: markets would under-produce "public interest" outputs. Grounded in the genesis of spectrum allocation for radio broadcasting, policy makers opposed market-driven rights allocations because they would "emasculate 'socially desirable' censorship."[72] But many analysts went much further, asserting that spectrum could *only* be held by the government. Property rights could not be auctioned because they could not be defined. "Rights to use the spectrum are not susceptible to legal enforcement as are private property rights."[73] Airwave spillovers led to economic externalities, which would destroy market allocation – that was the theory-driven story. When Coase explained the actual problem as delimiting rights, which could be achieved using one set of rules or the other (public ownership v. private ownership), the response from academic and policy experts was emphatically negative.

Invited to the FCC to testify about his novel approach to spectrum allocation in 1959, the first question posed was Commissioner Philip Cross' query: "Tell us, Professor, is this all a big joke?"[74] In 1962, the Rand Corporation commissioned Coase and two other economists to write a detailed proposal to implement the suggested policy regime. Rand then suppressed the 200-page report when the think tank was warned of its potentially explosive political implications.[75] In 1965, a Federal Communications Commission official explained why the response to Coase

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[71] This position is sometimes labeled a "pure property rights" position. In fact, no property rights regime is "pure," because boundary conditions and enforcement choices are always subject to cost-benefit tests. Moreover, rival property rights conflict, such that the efficient path is to curtail one set of ownership rights on margins where other ownership rules are likely to be more productive. David Friedman, explaining the general efficiency goal of bundling initial rights assignments in ways that reflect how resources will be most effectively utilized (and so avoiding subsequent transaction costs), informs the analysis with the following examples. Land owners do not possess airspace rights to 40,000 feet in the sky, allowing commercial airliners to fly without negotiating with property owners of the underlying ground space (and avoiding tragedy of the anti-commons). Mobile wireless carriers, similarly, are awarded "wide area" rights to control frequency space, avoiding tragedy. Friedman, LAW'S ORDER (Princeton, NJ: Princeton Univ. Press; 2000), p. __. The same analysis suggests that very low power emissions providing small, localized applications may also be efficiently vested in local landowners, who can themselves police (local) conflicts. If such emissions are neither useful for wide area communications nor damaging to them when conducted simultaneously, allowing such rights to be held by real property owners efficiently cedes jurisdiction from spectrum owners to land owners. Such allowances for "de minimus interference" is inherently a part of any regime, including the state property regime where the FCC allows very low power ("Part 15") devices to generally operate in licensed bands. On the general problem of assigning rights so as to reduce subsequent transaction costs, see Harold Demsetz, *When Does the Rule of Liability Matter?* 1 J LEGAL STUD 13 (1972).

[72] As economist Jora Minasian stated the argument against auctions. Jora Minasian, *Property Rights in Radiation: An Alternative Approach to Radio Frequency Allocation*, 18 J L & ECON 221 (1975), 268.

[73] William H. Melody, *Radio Spectrum Allocation: Role of the Market*, 70 AM ECON REV 393 (May 1980), 392.

[74] R. H. Coase, *Law and Economics at Chicago*, 36 J LAW & ECON 239 (1993).

[75] The episode is explained in R. H. Coase, *Assigning Property Rights to Radio Spectrum Users: Why Did FCC License Auctions Take 67 Years?: Comment on Hazlett*, 41 J L & ECON 576 (Oct. 1998). The 1962 paper was finally released by Rand in 1995 – one year after FCC auctions commenced. Coase, Meckling & Minasian (1995).

was so uniformly hostile: "After the initial shock of rationally considering the use of the pricing mechanism in frequency allocations, the virtually unanimous view of communications specialists would be that the multiplicity of users both national and international…, the interference characteristics of radio with signals at relatively low energy levels interfering at diverse points many hundreds of miles away… and the hundreds of thousands of licensees involved in addition to the many millions of consumers make the pricing mechanism unworkable for frequency allocation."[76] When, in the mid-1970s, Coase's call for auctions was (finally) taken up by an FCC member, it was promptly ridiculed by two fellow Commissioners who announced that its adoption garnered the same odds "as those on the Easter Bunny in the Preakness."[77]

The intense opposition to competitive bidding was curious to Coase. The arguments were made that (1) radio emission rights could not be defined to be sold; (2) even if such rights could be traded, market assignments would under-supply public interest outputs like local news or educational programming. But the first premise was demonstrably untrue, as the licenses that were assigned by regulators were routinely re-assigned by the price system; secondary market transactions had been revealing the existence of substantial rents since the 1920s. And the second seemed to Coase to clash with common sense. The conditions placed on licensees could be imposed in a regime where licenses were distributed by auction, with rents (reduced by the expected costs of the embedded obligations) captured for the public. The objection to market assignments seemed simply to be in error.

Here Coase missed the political dynamics. One advantage of an auction regime is that it improves transparency, forcing regulators to state terms and conditions. But policy makers and broadcasters are able to generate mutual gains – trading rents for regulatory influence over content -- by incomplete revelation of terms.

Policy makers had good reasons to fear a loss of control over broadcasting were auctions to be implemented. Assigning rights to radio and television stations by competitive bidding rather than administrative fiat eliminated non-arms length transactions and thereby reduced the scope for "regulation by raised eyebrow" – a term of art at the FCC.[78] The license was commonly referenced as a *quid pro quo,* with rents awarded to licensees in exchange for "public interest" outputs.[79] In reality, the enumerated social benefits rarely materialized. By the FCC's own admission, the "public interest" programming gambit was a failure, producing a "vast wasteland," as FCC Chairman Newton Minow famously described TV fare in 1961.[80] In 1976, Commissioner Glen O. Robinson likened broadcast regulation to "a charade—a wrestling match

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[76] H. H. Goldin, *Discussion of "Evaluation of Public Policy Relating to Television and Radio Broadcasting: Social and Economic Issues" (Coase)*, 41 LAND ECON 167 (May 1965), 168.

[77] *Broadcast Renewal Applicant*, 66 F.C.C.2d 419, 434 n.2 (1977) (Commissioners Hooks & Fogarty, separate statement). See Glen O. Robinson, *The Federal Communications Commission: An Essay on Regulatory Watchdogs*, 64 VA L R 169 (Mar., 1978), 243.

[78] The term, coined by Nixon-appointed FCC Chair Dean Burch, has been defined by federal courts this way: "Thus, licensee political or artistic expression is particularly vulnerable to the 'raised eyebrow' of the FCC; faced with the threat of economic injury, the licensee will choose in many cases to avoid controversial speech in order to forestall that injury. Examples of this process are legion." *Illinois Citizens Committee for Broadcasting v. FCC*, 169 U.S. App. D.C. 166, 515 F.2d 397 (1974)

[79] See, e.g., Thomas W. Hazlett & Matthew L. Spitzer, *Digital Television and the Quid Pro Quo*, 2 BUS & POLITICS (2000).

[80] Newton R. Minow, EQUAL TIME: THE PRIVATE BROADCASTER AND THE PUBLIC INTEREST (1964), 45-69.

full of fake grunts and groans but signifying nothing.''[81] As economist Bruce Owen deduced from the empirical evidence, the FCC "does not live up to its own theory of regulation."[82]

Yet the lack of productive outputs did not mean that the regime was not a success in achieving certain politically popular ends. Evidence of that success was seen in the extreme hostility to auctions cited above, and in the fact that is was particularly concentrated among those who benefited the most from the exercise of power over assignments -- committees in Congress overseeing FCC operations. While budget and appropriations committees had long sought to obtain revenues from licenses, the respective commerce committees (overseeing telecommunications regulation) blocked reform. In Feb. 1987, Sen. Warren Rudman (R-NH), a member of the Senate Commerce Committee, sprayed cold water on the Federal Communications Commission proposal to authorize license sales because it ``will aid monopolies…. You won't get anywhere with this, so why don't you go back to the drawing board?"[83] In May 1987, Sen. Daniel Inouye (D-HI), Chair of the Senate Subcommittee on Communications, rebuffed a colleague, Sen. Lawton Chiles (D-FL), Chair of the Senate Budget Committee, telling him that an auction "undercuts the fundamental tenet in communications policy that the airwaves are a limited public resource [and it] is inappropriate to sell such a resource to the highest bidder."[84] The Chair of the House Commerce Committee, John Dingell (D-MI), then introduced 1989 legislation with a section: "PROHIBITION OF SPECTRUM AUCTION."[85] The bill was simply a blunt object waved in a threatening manner; the FCC had no statutory authority to conduct auctions.

Yet this political animosity was dissipating over time. Broadcasting – the object of the "fundamental tenet in communications policy" – was being eclipsed in economic importance by emerging wireless telephone services. In 1993, with U.S. policy for second generation (2G) services lagging, with a newly unified national government (the Democratic Party controlled both the Presidency and the Congress for the first time in 12 years), with the transparent squandering of billions of dollars in rents in the 1984-89 cellular license lotteries as predicate, the system was primed for reform.[86] Congress authorized auctions in the 1993 budget, mandating that they be used to distribute PCS, but not broadcasting, licenses and gave the Federal Communications Commission a one-year deadline to initiate competitive bidding.[87]

The demonstration effect was powerful. Once sales commenced, distributing licenses economically, the consensus of the communications experts was exposed and broken.[88] The

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[81] As quoted in Henry Geller, 1995-2005: REGULATORY REFORM FOR PRINCIPAL ELECTRONIC MEDIA (1994), 15.

[82] Bruce M. Owen, *Differing Media, Differing Treatment?* in D. Brenner & W. Rivers, eds., FREE BUT REGULATED: CONFLICTING TRADITIONS IN MEDIA LAW 35 (1982), 36.

[83] Evan R. Kwerel & Gregory L. Rosston, *An Insiders' View of FCC Spectrum Auctions*, 17 JOURNAL OF REGULATORY ECONOMICS 253 (2000), 258.

[84] Ibid.

[85] Ibid.

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

[87] The process by which the FCC acted quickly to create an auction mechanism is described in Evan Kwerel's Preface to Milgrom (2004). Dr. Kwerel, then and now a Senior Economist at the FCC, was the FCC official who led the agency's auction planning.

[88] Auction rules employed by the FCC were crafted on a strict timeline and reflected an understanding that initial auction outcomes were politically important. Were haphazard procedures to produce confusion, legal challenges, or

burden shifted: *what was to justify a system in which licenses were not assigned to high bidders?* Moreover, the new flow of federal receipts shifted the political equilibrium. Stalwart opponents of auctions now sought to take credit. Pedestrians in Washington D.C. found it hazardous to inadvertently stroll between a television news crew and an FCC Chairman brandishing an auction check for the Treasury.[89] The Commission issued notices boasting that it was a government profit center.[90] While tantamount to a real estate agent assuming credit for the market value of the property sold, the claim did possess a germ of historical veracity: prior to 1994, the Government had squandered such rents in favor of "beauty contests" and lotteries.[91]

Worse for democratic institutions, government policy makers were enmeshed in a fundamental conflict of interest, setting rules for electronic speech, including content regulations such as the "equal time rule" (imposed by statute in 1927) and the "fairness doctrine" (imposed by the FCC in 1949), while their electoral fortunes relied on the information supplied to the public by these media outlets. Even in arms length oversight, regulators were constrained to evaluate licensees with regard to political considerations. And not always were regulations arms length. Texas Congressman Lyndon Johnson amassed a personal fortune by forming a political alliance with the chairman of the FCC, befriending staffers of the agency, and then manipulating regulatory decisions to land his wife under-priced ownership of TV and radio stations – a process called by one observer, "government between friends."[92] Later, when President of the United States, "Johnson would summon the appropriate CBS personnel to the White House to complain that CBS was charging one of his TV stations too much for syndicated programming." The problem was solved when CBS News President Frank Stanton "told his staff to furnish the program to the station free."[93] During the Nixon years, networks considered implicit threats of license renewal problems in response to purported media bias to be just another cost of doing business.[94] Coase, aware of the potential for such corruption and First Amendment compromise, argued for competitive bidding as an antidote.[95]

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long delays, the backlash might well eliminate the reforms. FCC staff, largely enthusiastic supporters of auctions, were influential in steering the Commission towards fairly simple auction formats, and to testing mechanisms prior to deployments. While we will see that such caution was soon compromised by the bidder subsidies extended in Auction 5 (May 1996), it was crucial that the first four auctions ran smoothly, resulted in orderly license assignments (and wireless deployments), and collected over $8 billion for the Treasury. See Kwerel & Rosston (2000); David Porter & Vernon L. Smith, *FCC License Auction Design: A 12 Year Experiment,* 3 J L ECON & POL'Y 63 (2006).

89 Auction receipts go to the U.S. Treasury, not the FCC. However, the FCC is allowed to claim a fraction of auction receipts to cover the cost of administering auctions. This fraction is not large.

90 After the March 1995 broadband PCS auction, the FCC "blew up a huge check [of $7.7 billion] to give the President. The picture ran in newspapers across the country. .. I told the press that the FCC had raised more money than its total budget for its 61-year history. We were, I said, the most profitable American business in terms of return on equity." Reed Hundt, YOU SAY YOU WANT A REVOLUTION (1999), 96. (Hundt was Chairman of the Federal Communications Commission, 1993-97.)

91 Evan Kwerel & Lex Felker, *Using Auctions to Select FCC Licensees*, Federal Communications Commission OPP Working Paper No. 16 (May 1985); http://www.fcc.gov/Bureaus/OPP/working_papers/oppwp16.pdf; Thomas W. Hazlett & Robert J. Michaels, *The Cost of Rent Seeking: Evidence from FCC Cellular License Lottories*, 53 SO ECON J 435 (Jan. 1993).

92 Robert Caro, THE YEARS OF LYNDON JOHNSON: MEANS OF ASCENT (New York: Vintage; 1991), 94.

93 William Ray, UPS AND DOWNS OF FCC REGULATION (Des Moines: Iowa State University Press, 1990), 41.

94 A Sept. 25, 1970 memo written by presidential aide Charles Colson to Nixon White House Press Secretary Herb Klein detailed meetings in New York City where Colson had recently visited the heads of all three commercial broadcasting networks, pressuring them to report on the Nixon Administration more favorably. "I had to break

The policy regime switch exposed a fundamental fact: the use of auctions was not revolutionary. Licenses that had been defined by policymakers before would continue to be defined, if governments so desired, in precisely the same manner. The traditional license, as allocated to television broadcasting, affords a right to operate a wireless business as strictly defined by the license. Transmission technology, business models (ad supported, not subscription), services (broadcast video, not two-way broadband), and even the location of transmitters were specified by regulators. Indeed, for TV and many other services, it still is: "almost all spectrum licenses have restrictions that specify the particular use to which bandwidth must be put."[96] The auction reform formally leaves this regime intact.

U.S. auctions have generally produced results anticipated by Coase. Large numbers of licenses have been sold, substantial revenues have been generated for the government, and blocks of spectrum have been more efficiently aggregated, invigorating retail competition.[97] Similar licenses have sold for similar prices, adjusting for timing and other financial differences, and for synergies between licenses.[98] And with over $52 billion in revenues collected by the U.S. Government, perhaps about $17 billion in additional economic welfare has been delivered via the public financing bonus. This occurs when rents are extracted that displace revenues generated by activity-distorting taxation, the rule of thumb associating each dollar of public receipts with approximately 33¢ in (additional) lost benefits.[99]

IV. EFFICIENCIES OF LICENSE AUCTIONS

Assigning wireless licenses by competitive bidding has markedly improved the administrative process wherein spectrum rights are awarded to licensees.[100] Efficiencies include private sector savings on lobbying activity associated with "comparative hearings," contests to establish the "public interest" bona fides of rival bidders for licenses. They are also an improvement over lotteries, authorized for use by the U.S. Congress in 1981 as a compromise (Congress not wanting to grant the Reagan Administration auction authority), which were

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every meeting. The networks badly want to have these kinds of discussions which they said they had had with other Administrations but never with ours. They told me any time we had a complaint about slanted coverage for me to call them directly. [CBS President Ed] Paley said that he would like to come down to Washington and spend time with me anytime that I wanted. M In short, they are very much afraid of us and are trying hard to prove they are 'good guys.'" Quoted in David L. Bazelon, *FCC Regulation of the Telecommunications Press*, 1975 DUKE L J 213 (May 1975), p. 246.

[95] Coase (1965).

[96] Gerald R. Faulhaber, *The Future of Wireless Telecommunications: Spectrum as a Critical Resource*, 18 INFO ECON & POL'Y 256 (2006), 262.

[97] Federal Communications Commission, *FCC Report to Congress on Spectrum Auctions*, WT Docket No. 97-150 (Oct. 9, 1997), 22.

[98] Lawrence Ausubel, Peter Cramton, Preston McAfee and John McMillan, *Synergies in Wireless Telephony: Evidence from the Broadband PCS Auctions*, 6 J ECON & MGT STRAT 497 (1997); Patrick Moreton & Pablo Spiller, *What's In the Air: Interlicense Synergies in the Federal Communications Commission's Broadband Personal Communications Service Spectrum Auctions*, 41 J L & ECON 677 (Oct. 1998).

[99] Paul Klemperer, *What Really Matters in Auction Design*, 16 J ECON PERS 169 (Winter 2002), 179.

[100] Peter Cramton, *Spectrum Auctions*, M. Cave, et al., eds., HANDBOOK OF TELECOMMUNICATIONS ECONOMICS VOL. I 605 (2002).

curiously conducted under the fiction that those applying for random selection were actual phone companies. Thousands of new "phone companies" materialized, on paper, submitting detailed engineering drawings and proof of operating experience, such evidence purchased from consulting firms and technology suppliers at considerable cost.[101] This charade created such massive filings, with hundreds of thousands of applications submitted for 1,468 cellular licenses (two issued in each of 734 franchise areas), that an FCC warehouse storing these documents collapsed. Between $500 million and $1 billion was squandered in rent seeking waste.[102]

But the largest costs were borne by consumers, technology suppliers, and investors after the non-auctioned licenses were assigned. Given U.S. regulators' penchant for issuing large numbers of geographically (and, often, spectrally) small licenses, extensive secondary market transactions were needed to assembly efficient spectrum blocks. To serve a national marketplace with mobile wireless, e.g., operators have acquired literally thousands of licenses – more than 50,000 FCC wireless licenses are today held by mobile carriers (of which there are just four national operators).[103] Such aggregations have been expensive; an estimated $190 million on brokers' fees alone was spent in 1991 in cellular license deals.[104]

More deleteriously, it took years to collect assets, delaying and degrading services.[105] The use of auctions in the primary market has speeded this process, reducing social expense. Paul Milgrom references the general set of transaction costs involved in reconfiguring license rights in secondary markets in writing:

> The history of the US wireless telephone service offers direct evidence that the fragmented and inefficient initial distribution of rights was not quickly correctable by market transactions. Despite demands from consumers for nationwide networks and the demonstrated successes of similarly wide networks in Europe, such networks were slow to develop in the United States.[106]

Such post-assignment delays were mitigated with the use of auctions. In the important PCS A, B auction, held from Dec. 1994 to March 1995, one firm – Sprint – emerged with 29 of 51 licenses needed for complete national coverage using 30 MHz. This yielded Sprint – a new mobile entrant -- direct access to 147 million potential subscribers (more than half U.S. population).[107] With roaming agreements, themselves easier to execute given the defragmentation of licenses elsewhere, Sprint began providing services by late 1995. This foray, along with additional regional network consolidations enabled in the PCS A/B auction and the

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[101] The forms verified that a group of investors could build and operate a cellular phone company, proof of which was purchased from actual telecommunications suppliers in exchange for contracts to provide such services (contingent on the lottery applicants being selected).

[102] Thomas W. Hazlett & Robert J. Michaels, *The Cost of Rent Seeking: Evidence from Cellular Telephone License Lotteries*, 53 SO ECON J 425 (Jan. 1993).

[103] Thomas W. Hazlett, *Is Federal Pre-emption Efficient in Cellular Phone Regulation?* 56 FED COMM L J 155 (Dec. 2003).

[104] Federal Communications Commission, *FCC Report to Congress on Spectrum Auctions*, WT Docket No. 97-150 (Oct. 9, 1997), 22.

[105] Total aggregation costs would include the services deterred due to delayed network buildouts, as well as negotiating costs incurred to deal with strategic hold-outs.

[106] Paul Milgrom, PUTTING AUCTION THEORY TO WORK (2004), 20.

[107] Harold Gruber, THE ECONOMICS OF MOBILE TELECOMMUNICATIONS (2005), 238.

formation of Nextel,[108] disrupted the existing cellular duopoly imposed by virtual of the fact that just two FCC licenses had been issued in each local franchise area.

The auction exposed the fact that mobile licenses were complements; significant value was created when adjacent licenses were purchased by bidders.[109] Productive gains were possible via the assembly of efficient packages, eliminating uneconomic rights distributions.[110] Of course, PCS licenses also enabled competitive entry, ending the cellular duopoly. Large gains to consumers ensued. Wireless carriers undercut terrestrial long-distance charges, encouraging substitution from fixed to mobile networks. The key marketing innovation began in May 1998 with instantly popular digital "one rate plans," offering large buckets of "nationwide minutes."[111]

As seen in Figure 1, average revenue per minute fell from over 50 cents prior to the PCS auction to just 6.4 cents in 2007, a nominal reduction of 87% -- at least 70% below the pre-PCS trend. Most of this sharp decline was achieved via a huge increase in minutes of use, encouraged by flat rate pricing (capped during peak calling times, unlimited off-peak).

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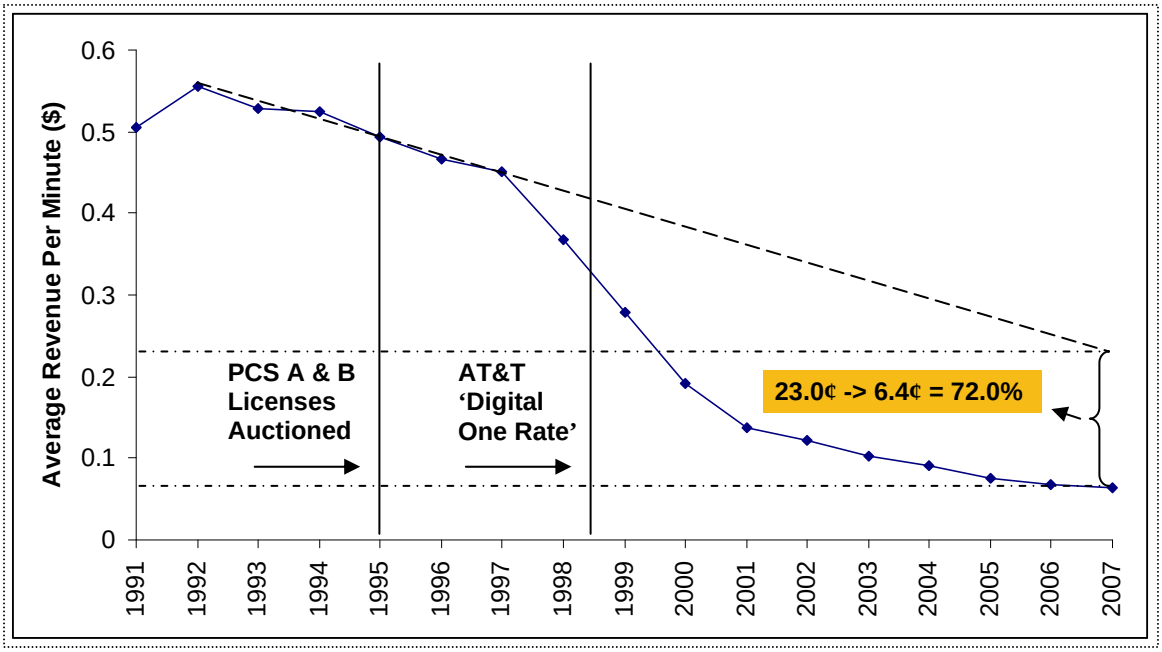
[108] Fleet Call was a wireless operator built on so-called taxi dispatch licenses, officially known as Specialized Mobile Radio (SMR) services. An entrepreneurial former FCC lawyer, Morgan O'Brien, purchased rights to many of these licenses, allocated 800 MHz and 900 MHz spectrum (very near cellular frequencies) and obtained permission from the regulator in 1990 to replace analog systems with digital technologies. In a lobbying coup for the upstart, the request (heavily opposed by incumbent cellular operators) was granted. This enabled the firm, renamed Nextel, to operate on up to 15 MHz. See Thomas W. Hazlett, *The Wireless Craze, the Unlimited Bandwidth Myth, the Spectrum Auctions Faux Pas, and the Punchline to Ronald Coase's 'Big Joke': An Essay on Airwave Allocation Policy,* 14 HARVARD JOURNAL OF LAW & TECHNOLOGY 335 (Spring 2001), 387-88. Nextel served 12 million subscribers before being sold to Sprint for $35 billion in 2005.

[109] See Lawrence Ausubel, Peter Cramton, Preston McAfee and John McMillan, *Synergies in Wireless Telephony: Evidence from the Broadband PCS Auctions*, 6 JOURNAL OF ECONOMICS & MANAGEMENT STRATEGY 497 (1997); (1997); Patrick Moreton & Pablo Spiller, *What's In the Air: Interlicense Synergies in the Federal Communications Commission's Broadband Personal Communications Service Spectrum Auctions,* 41 JOURNAL OF LAW & ECONOMICS 677 (Oct. 1998).

[110] This was also seen in the substantial premium paid by bidders for the large regional licenses in Auction 66 (for Advanced Wireless Services licenses) in Sept. 2006. See analysis below.

[111] Federal Communications Commission, *CMRS Fifth Annual Report* (2000).

FIG. 1. U.S. CELLULAR RETAIL PRICES BEFORE AND AFTER PCS AUCTIONS[112]



Competitive bidding for licenses may have encouraged regulators to continue to divvy up airwave rights in highly fragmented parcels. In 73 auctions conducted by the FCC, July 1994 through November 2008, the Commission sold some 27,484 licenses.[113] This radical (and globally distinct) fragmentation of licenses has been partially mitigated by the implementation of auctions.[114]

Revenues generated by license auctions have assumed both economic and political importance. To economists, the rents transferred to governments create public financing efficiencies. Each dollar raised theoretically offsets another dollar which would have – but for the auction receipts – been raised via taxes. Because taxes generally distort economic activity, funds raised cost society more than they buy for the government. Capturing spectrum rents can be an efficient way to pay for public expenditures.

But not if the spectrum allocation system distorts wireless markets in order to increase bidding receipts. There is a sharp conflict between government maximizing its revenue as a monopoly seller, and an efficient allocation for long run income creation benefiting the economy (and, indirectly, generating additional tax collections). Because license revenues are easily dominated by consumer surplus generated by the wireless services enabled (Hazlett & Muñoz 2009), it is penny-wise and pound foolish to restrict competition (or, equivalently, delay license sales) in order to goose up auction receipts. This, unfortunately, is a lesson that must still be learned by the political system, as discussed below.

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[112] CTIA data.

[113] FCC website. The number is slightly inflated by the re-auction of some licenses.

[114] Aggregation problems exacerbated by the lack of combination bidding are discussed below.

V. INEFFICIENCIES IN THE LICENSE AUCTION REGIME

1. Bidder Collusion

FCC auction procedures initially gave bidders incentives to signal – and collude – by using bids that detailed what markets they were most keenly interested in winning. Communications were achieved by placing bids that used the last three decimal places to mark desired territory. A bid of $36,000,326, say, would indicate a decided interest in the bidder winning License No. 326. This bidding strategy was labeled the *trailing digits play*.

To eliminate this practice, the FCC no longer allows bidders to submit their own (custom) bid amounts; they must select from incremental bids specified by the FCC.[115] Other methods employed by bidders may signal their intentions, however. One of the most pervasive strategies, which has garnered attention in the economics literature, is that of *jump bidding*. This strategy registers bids one or more increments above the prescribed minimum. The approach is designed to signal the strength of the bidder, "scaring away" rivals contesting a license. It may also secure a license for which the bidder may not have the highest value, but where a higher bidder's valuation proves less than the winning bid *plus* the minimum increment.[116] Another strategy, euphemistically called *upping yourself,* occurs when a bidder increases their own bid despite being the standing high bid on a license. Ordinarily, this is viewed as a patently irrational action in auction theory. Yet, in FCC license auctions, it has been associated with the same signaling strategies as those associated with jump bidding.

The strategy of *retaliatory bidding* entails placing bids on the licenses bid upon by rivals, restricting the rival's ability to bid on the licenses the bidder actually desires to win. For example, if a bidder is interested in license A and another bidder is interested in licenses A and B, the first bidder can drive up the price of B, signaling that the second bidder should cease bidding on A. Many bidding strategies have emerged, and a host of FCC rules on bidder eligibility and withdrawal have been adopted in response. Insofar as collusive strategies arise, they stem from regulator's provision of full information on bidder identities, bids submitted, and other information. Banks et al. (2002)[117] make a case for not providing such information in these types of open auctions. Beginning in 2008 (Auction 73) the FCC adopted anonymous bidding, revealing only the number of bidders who place bids for each license and the amount of the current highest.[118] Such non-disclosure rules have benefits but also costs, in that firm executives are bound by extensive FCC regulations regarding inter-firm communications, rules adopted to protect the secrecy of bidder identities.

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[115] Peter Cramton & Jesse A. Schwartz, *Collusive Bidding in the FCC Spectrum Auctions*, 1 CONTRIB ECON AN & POL'Y (2002); Patrick Bajari & Jungwon Yeo, *Auction Design and Tacit Collusion in FCC Spectrum Auctions*, NBER Working Paper 14441 (Oct. 2008); http://www.nber.org/papers/w14441.

[116] Jump bidding is also used to ensure that one's bid is not tied, in which case, one of the tied bids is randomly selected to be the provisionally winning bid, and the others are discarded.

[117] Jeffrey Banks, Mark Olson, David Porter, Steve Rassenti & Vernon Smith, *Theory, Experiment and the Federal Communications Commission Spectrum Auctions*, J ECON BEHAVIOR & ORG (2002).

[118] Details of the basic FCC auction design are discussed in Porter & Smith (2006).

While many of the flaws in the FCC rules were anticipated by the experimental economics literature it appears many of the flaws are fixable and have been, fixed. "A close examination of the problems experienced in the US in the middle of the 1990s, however, shows that they were relatively minor glitches to a very successful program of spectrum assignment."[119] That is the mainstream view, and it garners justifiable support. However, as we will argue below, one major change in the auction format, combinatorial bidding, should be implemented.

2. Bidding Credits for Designated Entities

In the 1993 legislation authorizing auctions, Congress mandated that the FCC conduct its competitive bidding procedures so as to fully include "designated entities" (DEs). These were defined as four types of companies: small businesses, rural telephone carriers, minority-owned firms, female-owned firms. Due to a U.S. Supreme Court case sharply limiting the use of government preferences assigned on the basis of race or gender,[120] the FCC dropped the latter two categories. Small businesses and rural carriers, as defined by the Commission, would be eligible for favorable treatment to effectively subsidize their bidding as per a policy crafted in 1995.[121] The rationale was that these companies were handicapped in accessing capital markets; in an open auction without such government protection, larger firms would out-bid them. Both bidding credits were extended, and license set-asides (barring bids from non-DEs) were imposed to remedy this situation.

This was not well thought out. Put yourself in the position of a bidder who could use credits (other peoples' money) to supplement whatever would have been your cash bid. The bidding credits induced over-bidding in auctions, producing winning bids much higher than those registered for similar licenses awarded without DE credits. That the bidding credits were extended as low-interest long-term loans exacerbated the effect; bids net of the credits were far above the non-subsidized bids in previous PCS auctions. The ensuing defaults and bankruptcies that occurred were a direct product of the fact that the firms granted such credits were neither efficient service providers nor, therefore, strong bidders. By encouraging awards to inefficient firms, the main purpose of the auction was thwarted. And it fails to incorporate the salient fact that, by sacrificing up front auction revenue in favor of efficiency increases (in service markets) and wealth creation, much greater downstream government tax revenue will be captured.

This reveals the severe tension between auctions and preferences. When a "small business" is afforded a bidding credit, it attracts more intense bidding, wiping out the advantage afforded. This outcome was virtually assured by the designation "small business," and the rules that the FCC used to define such entities: firms with limited financial resources (including collateral). This approach was explicitly taken to help firms that would otherwise have difficulty obtaining credit in order to bid for licenses. But the reason that firms without financial standing have limited access to capital markets is that such firms are relatively bad bets.

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[119] Mark Scanlan, *Hiccups in US Spectrum Auctions*, 25 TELECOMMUNICATIONS POLICY 689 (2001), 690.

[120] *Adarand Constructors v. Pena*, 515 U.S. 200 (1995).

[121] *Implementation of Section 309(j) of the Communications Act – Competitive Bidding, Fifth Report and Order*, 9 FCC Rcd 5532, ¶ 115 (1994).

In the 1996 PCS C block auction (No. 5), the FCC saw winning bids more than twice as high, net of bidding credits, as had been paid in the (unsubsidized PCS A and B) auction the year before.[122] DE bidders extended 40% bidding credits. (In other words, if a DE bids 100, that bid is registered as 140 in the auction but, were the DE bidder to win, would pay just 100.) And DEs were allowed to pay winning bids over ten years, interest-only for the first four, at an interest rate equal to that on long-term U.S. Treasury Bonds (then about 6.5%). This constituted a considerable financing subsidy for firms' whose cost of capital would have been about 14%.[123]

Moreover, it created a lucrative financial option. Bidders could bid aggressively to win, make their first interest-only payment, then see whether license value exceeded what they had bid. If so, they would finance their network, build-out, and then pay the government. If not, they could declare bankruptcy and seek protection from their creditor – the federal government. Indeed, they could ask a bankruptcy court to reduce their obligation. That is what the largest C block winners did.[124] GWI bid about $1.1 billion for licenses, but received permission from a U.S. Bankruptcy Court to satisfy its debt by paying just $200 million. Nextwave, having emerged the largest PCS C winner in 1996 with $4.8 billion in licenses, ended up paying just $1.6 billion in cash to the FCC – two-thirds of which was paid, without interest, in 2004.[125]

By exacerbating winner's curse, and driving licenses to inefficient suppliers, the FCC destroyed huge increments of consumer welfare. PCS spectrum was allocated in 1989-94. Auction 5 (concluded May 1996) assigned C licenses and Auction 11 (concluded January 1997) assigned F licenses. It then took until settlements and transactions conducted in 2004 and FCC Auction 58 (concluded February 2005) to assign most C and F block license rights to operators. This deprived the mobile market of about 30 MHz of nationwide bandwidth, raising prices to retail customers. The loss in efficiency of this input truncation amounted to at least $65 billion.[126] This debacle, if attributed to the initiation of auctions, could well leave the policy with a net social value of less than zero.

The irony was that economists had greeted the bidding credits program enthusiastically, on the grounds that it would increase net auction receipts. By subsidizing rivals to established incumbent carriers, such carriers would be forced to bid more aggressively. The designated entities would not emerge victorious but serve as bidding shills used by "the house" to drive up the stakes of the game.[127] The analysis implicitly assumed that the government could calibrate the credits to perfectly strike a balance, driving up receipts without awarding licenses to sub-standard service suppliers. Prescience is an ambitious assumption for public policy. When

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[122] The DE set-asides and bidding credits are explained in Federal Communications Commission, *In the Matter of Eligibility Restrictions on C Block Licenses in the Broadband Personal Communication Services, Memorandum Opinion and Order*, RM-11019 (rel. Oct. 15, 2004), par. 2.

[123] Thomas W. Hazlett & Babette E.L. Boliek, *Use of Designated Entity Preferences in Assigning Wireless Licenses*, 51 FED COMM L J 639 (May 1999).

[124] Hazlett & Boliek (1999). PCS F block licenses auctioned in 1997 were also subject to the same subsidy rules

[125] Federal Communications Commission, *FCC Announces NextWave Settlement Agreement*, Press Release (April 20, 2004). NextWave also returned some of its licenses to the FCC.

[126] Thomas W. Hazlett & Roberto E. Muñoz, *A Welfare Analysis of Spectrum Allocation Policies*, 40 RAND J ECON 424 (Autumn 2009).

[127] Ian Ayres & Peter Cramton, *Deficit Reduction Through Diversity: How Affirmative Action at the FCC Increased Auction Competition*, 48 STAN L R 761 (1996).

violated, weak bidders actually win licenses, perform relatively poorly, and reduce consumer welfare. This is what happened endemically and sensationally in the PCS-C and PCS-F block auctions, as described, resulting in extremely large social losses. While the FCC no longer extends credit to winning bidders, it continues to favor weak bidders with bidding credits, raising the probability that productive efficiencies will be lost and output markets will exhibit degraded performance.[128]

3. License Fragmentation and the Lack of Package Bids

License fragmentation continues to unnecessarily complicate bidding strategies, exposing bidders attempting to create regional or national coverage areas to higher levels of risk than need be the case. The efficiency of property rights assignments is therein reduced. It also leads to relatively lengthy auctions that, combined with FCC non-disclosure rules, deter auction participation -- perversely reducing competitive network entry.

U.S. spectrum policy is unique in its reliance on extreme license fragmentation. Virtually all countries issue national licenses for mobile telephone service; a few countries issue large regional licenses.

In economic terms, the (easily) most important wireless market is for mobile phones. The FCC calls this Commercial Mobile Radio Services, or "CMRS," and it includes cellular, personal communications services (PCS), specialized mobile radio (SMR), advanced wireless services (AWS) and 700 MHz licenses. The FCC created 734 local cellular franchise areas, issuing two duopoly licenses in each. In PCS, multiple maps were used; A and B blocks consisted of 51 licenses nationwide; C, D, E and F of 493 licenses – 2,074 licenses in all. Today, including more than 47,000 SMR licenses (issued by local market and *channel*), there are at least 53,774 licenses used by U.S. mobile carriers. The equilibrium number of licenses appears to be somewhere about four (meaning four combinations of thousands of elemental licenses), given the fact that 90% percent of U.S. mobile service revenues are accounted for by Verizon, AT&T, Sprint and T-Mobile.[129]

The formats adopted for license auctions have reflected the "fragmentation preferences" of policy makers. Wireless operators bidding on licenses generally demand regional or nationwide spectrum inputs. This makes licenses complements. On the other hand, the existence of alternative license types within the same auction presents chances for substitution. At a small cost penalty (in the added complexity in base station and handset radios), bidders can aggregate licenses across bands to achieve their geographic coverage goals.

Taking this general spectrum allocation approach as a given, the economists who helped craft FCC auction rules saw that simple bidding formats – such as sealed bids – would not produce optimal results. Auctions would generate both greater revenue and more efficient

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[128] Ibid.

[129] Approximately 51,597 licenses were held by U.S. carriers in 2003, prior to the auction of 1,087 AWS licenses in Sept. 2006 and 1,090 700 MHz licenses in March 2008. See Appendix 1 for a summary of U.S. license auctions. For the 2003 license distribution across regulatory categories, see Hazlett (2003), 193. Note that SMR licenses were largely assigned by the FCC prior to the advent of auctions, and then reassembled in secondary markets.

results (resources going to the most efficient operators) were values of complements and substitutes revealed as bids were being formulated. This led to the now familiar sequential ascending auction (SAA) format, also known as a sequential, multi-round auction (SMR).[130]

Inefficiencies yet arise, however, due to risks bidders face in assembling complementary sets of licenses. The solution to this problem is to include package (combinatorial) bids. The FCC rejected this path in 1994, because combinatorial auctions have been thought to face difficult computational issues, sometimes referred to by Michael Rothkopf as the 2^N *bogeyman*.[131] Despite substantial improvements in auction software and numerous FCC announcements (dating to 2000[132]) that it would adopt such methods,[133] the Commission has yet to widely deploy package bidding.[134] Indeed, the combinatorial clock auction discussed in Porter et al. (2003) has been shown to be highly efficient and does not needlessly suffer from the dreaded bogeyman.

With such a mechanism, firms could bid for the set of licenses they desire. Otherwise, they are forced to bid for each license individually, uncertain of the prices they will have to pay to obtain complementary assets. This uncertainty is the source of "aggregation risk."[135] To achieve national coverage, a new entrant must bid on scores of properties without knowing how high prices will go. Should the firm emerge as the high bidder on a number of licenses, but then see prices for complementary licenses climb higher than anticipated, it will be forced to make difficult choices. Either it will exceed its budget, or attempt to exit the auction. The problem with the latter is that there is no guarantee that it will be outbid on all licenses where it is currently the provisional winning bidder. If it holds some fraction of its intended coverage map when the auction ends, it's best option may then be to liquidate at fire sale prices.

Rules to mitigate this effect—short of combinatorial auction forms that allow bidders to select packages in real time—appear to have backfired. It has been shown that an FCC rule allowing bid withdrawals (with penalties), designed to lessen the impact of failed aggregations, actually results in more losses when licenses have strong complementarities.[136] Hence, firms can easily find themselves having to unload holdings at fire sale prices post-auction, or upping bids to buy 'fill-in' licenses at higher prices than it estimated to be profitable. Firms can avoid either position by simply choosing not to enter the auction in the first place.[137]

Hence, aggregation risk diminishes competitive bidding, lowering revenues and potentially decreasing efficiency in the output market. One indication that this risk is substantial

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130 Porter & Smith (2006), 65-66. See also, Milgrom (2004).

131 Porter & Smith (2006)

132 Federal Communications Commission, Conference on Combinatorial Bidding (May 5-7, 2000), agenda here: http://wireless.fcc.gov/auctions/default.htm? job=conference_agenda&y=2000.

133 Ibid.

134 The 700 MHz auction (No. 73) in March 2008 allowed package bids for the 12 large regional licenses, but not for the 1,100 other licenses. Obviously, package bidding is most useful in rationalizing the smaller licenses.

135 Mark M. Bykowsky, Robert J. Cull, & John O. Ledyard, *Mutually Destructive Bidding: The FCC Auction Design Problem*, 17 J REG ECON 205 (May 2000).

136 David Porter, *The Effect of Bid Withdrawal in a Multi-Object Auction*, 4 REV ECON DESIGN 73 (Feb. 1999).

137 Jeremy Bulow, Jonathan Levin, and Paul Milgrom, *Winning Play in Spectrum Auctions*, NBER Working Paper 14765 (March 2009).

is seen in the premium generally paid for larger licenses where size is measured in license area population ("pops") or in frequency space (MHz), as in the 2006 AWS auction. See Figure 3. Large regional licenses – D, E, F (12 licenses covering the U.S.) – generally sold for substantially more than did smaller licenses – A (734 licenses), B (176), C (176).[138] The F block, with 20 MHz, sold for more than D and E blocks, allocated 10 MHz each. The larger B and C licenses sold for more than did the smallest licenses, in A.

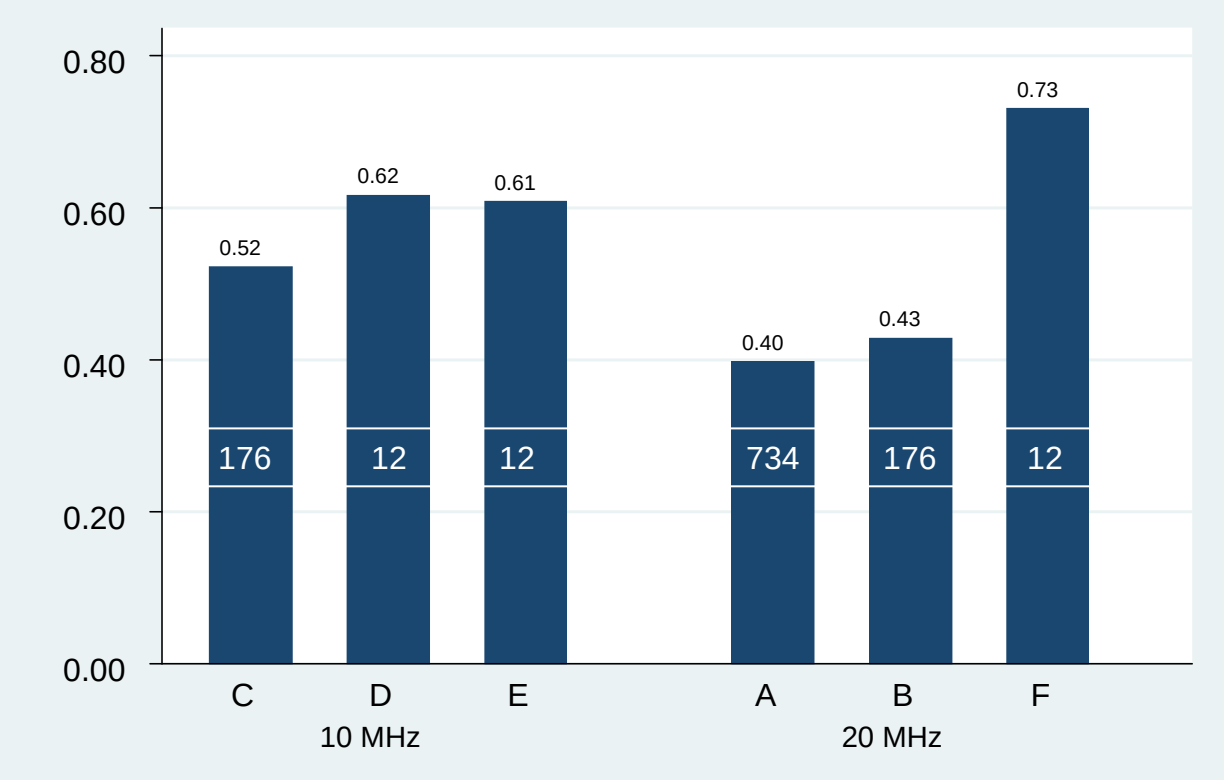
There was one important anomaly, however, in B license prices. The B band – 20 MHz allocated to 176 licenses – was less expensive than the C band – with 10 MHz distributed across 176 licenses. The (176) B licenses were also cheaper than the (734) A licenses. Almost all B licenses were won by SpectrumCo, a consortium of cable companies that held no existing wireless assets. Bazelon (2009) argues that the AWS auction, including the small slicing of licenses and the lack of package bidding, was efficient given that an entrant successfully acquired 20 MHz of national coverage at a price of $2.4 billion – saving $1 billion to $1.5 billion versus what the other two largest auction winners (T-Mobile and Verizon) paid. That was a remarkable outcome.[139] Bulow, Levin & Milgrom (2009) detail the bidding strategy of SpectrumCo as highly successful, particularly its early use of a nine-increment jump bid (the largest allowed under the AWS rules). From a social standpoint, however, such price differentials suggest that the input market has yet to reflect competitive equilibrium. Auction rules should invite bidders to purchase productive assets at competitive prices, not hire expensive strategy consultants to overcome aggregation risk.[140]

[138] License prices are generally quoted in $price/MHz/pop, a convention we follow here.

[139] Coleman Bazelon, *Too Many Goals: Problems with the 700 MHz Auction*, 21 INFO ECON & POL'Y 115 (2009).

[140] A disclosure may be of interest: Coleman Bazelon, Jeremy Bulow, Jonathan Levin, Paul Milgrom, Thomas Hazlett and David Porter all served as consultants to SpectrumCo.

Fig. 2. Mean Prices for Different-Sized Licenses in the AWS Auction (Sept. 2006)



Two basic policy reforms would promote further progress. The first, discussed above, would provide for package bidding in auctions. The second entails further liberalization of spectrum use, allowing market access – via liberal licenses -- to more bandwidth. This would increase market liquidity, eliminating price differentials. Engorging the supply side would, of course, extend productive opportunities and liquefy capital markets where wireless service providers shop for spectrum inputs.[141] We discuss the general efficiencies of this approach below.

4. Under-allocation of Radio Spectrum Ownership Rights

License auctions do not reform the underlying resource allocation system. Hence, they do not solve the essential social coordination problem confronted in Coase (1959): how to make most efficient use of radio spectrum. That is because the rights auctioned by regulators are yet created by administrative allocation, the state property regime imposed by policy makers on the premise that "the invisible resource"[142] did not admit to private ownership.

[141] Kwerel & Williams (2002).

[142] Harvey J. Levin, THE INVISIBLE RESOURCE: USE AND REGULATION OF THE RADIO SPECTRUM (Baltimore: Johns Hopkins University Press; 1971). The late Prof. Levin's work is cited for its apt phrase, not for the analytical errors made by regulators – and corrected by both Coase and Levin.

The general liberalization of spectrum property rights is the more ambitious public policy enterprise. While it has witnessed less decisive adoption than auctions, it has achieved more far-reaching success in economic welfare terms. As in other countries, the FCC has afforded wide discretion – what it calls "flexible use" – to licensees in particular cases, most notably in mobile telecommunications service licenses.[143] This has proven a powerful "proof of concept" for spectrum property rights, Coase's principal normative recommendation. Exclusive ownership rights have been implemented without major strain (indeed, barely any institutional notice) on the regulatory system. Competitive licensees, endowed with control of bandwidth, have coordinated complex economic activities that would be less efficiently supplied under alternative rules, ushering in waves of welfare-enhancing investment and innovation. There is no serious opposition to the proposition that "flexible use" has offered substantial improvements over the "command and control" mechanisms of the state property regime.[144]

Exclusive ownership rights enable spectrum markets to allocate bandwidth. Important efficiency conditions are revealed. Trades are commonly made in bundled form, combining airwave access with network services.[145] Wireless carriers retain integrated control over bandwidth and complementary communications infrastructure. Resources are nonetheless shared, *intensely*. A mobile phone network will sell bundled access to millions of subscribers, dozens of wireless service retailers (such as virtual network operators), and thousands of application providers. These latter may contract directly with the network (as when customers of Amazon download books on their Kindles, using the Sprint network but paying Amazon) or via vendors setting up their own wireless platforms (as when 85,000 Apple App Store applications come onto iPhones accessing the AT&T network via a contract with Apple).[146]

Administrative allocation yet imposes artificial scarcity. No more than about 12% of the total bandwidth under 3.5 GHz (the most valuable frequencies) is thusly allocated in the U.S.[147] Since the advent of auctions, which began with so-called second generation (2G) cellular licenses in the mid-1990s, further allocations have been slow. In the early 2000s, the FCC slowed the release of mobile licensed spectrum – 3G licenses – in favor of additional unlicensed bandwidth.[148] The Bush Administration explicitly delayed additional mobile license auctions in

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[143] Kwerel & Williams (2002); Hazlett & Spitzer (2006). The alert reader will note the irony in speaking of "flexible use" in the context of licenses crafted to provide a specific set of services (like "cellular telecommunications"). The Coasean path would lead to "spectrum licenses."

[144] FCC SPTFR (2002); Hatfield & Weiser (2006); Gerald R. Faulhaber, *The Future of Wireless Communications: Spectrum as a Critical Resource*, 18 INFO ECON & POL'Y 256 (2006); Philip J. Weiser, *The Untapped Promise of Wireless Spectrum*, Hamilton Project Paper 2008-08, Brookings Institution (July 2008).

[145] Of course, 'raw spectrum' changes hands in the form of license sales, secondary market activity that has long existed. Once networks are constructed, however, the ubiquitous business model is to retain spectrum control under one organizational roof, and share bandwidth by selling bundled access rights.

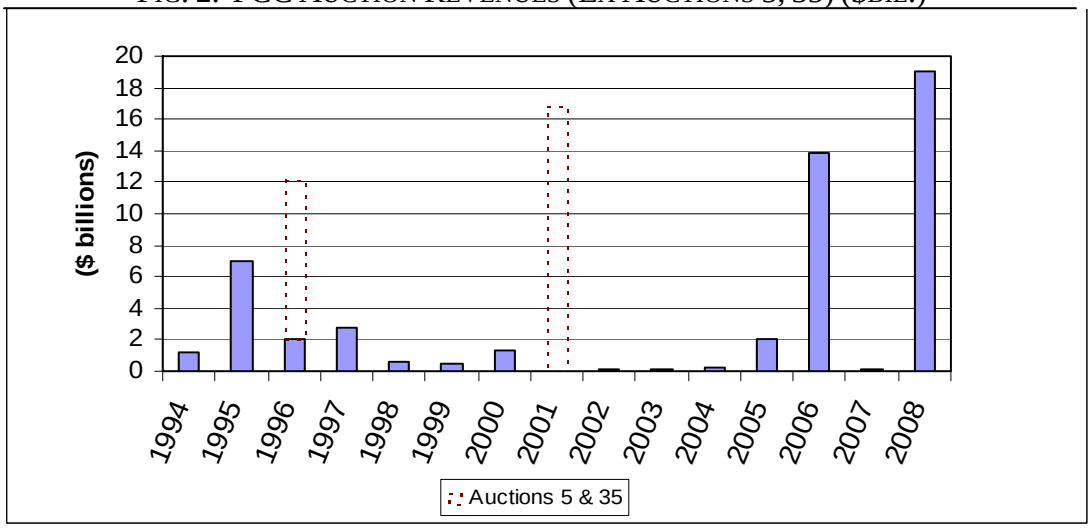
[146] Thomas W. Hazlett, *Modular Confines of Mobile Networks: Is the iPhone iPhony?* Paper presented at the GMU/Microsoft Conference on Innovation (May 2009).

[147] According to a survey of OECD members by the Cellular Telecommunications and Internet Association (Summer 2009), the U.S. has authorized 409 MHz for use by wireless carriers. (Of this, 142 MHz were allocated to licenses sold in 2006 and 2008, and the bandwidth has not yet been deployed. The AWS licenses auctioned in 2006 have incumbent clearing operations which continue to delay new mobile deployments.) This constitutes, 11.6% of the prime bandwidth under 3.5 GHz. Only 50 MHz was identified as being "in the pipeline" for new FCC authorizations.

[148] Kevin Werbach, *Supercommons: Toward a Unified Theory of Wireless Communications*, 82 TEX L R 863 (March 2004).

early 2001 on the grounds that such delays would be a "win win."[149] The dual gains came from helping wireless carriers, which claimed that they were then facing an economic downturn and did not need more bandwidth, and government coffers, which were estimated to receive higher revenues if sales were pushed back several years. Missing from this *starving man theory of restaurant management* (the customers will pay more if you wait until they're *really* hungry) was any consideration of consumer welfare. Despite the explosive growth in wireless services and burgeoning demand for spectrum inputs by carriers, the period 1996 through 2005 saw the release of no new bandwidth for mobile services, constraining network expansion, as reflected in the dearth of auction revenues generated during these years. See Figure 2.

FIG. 2. FCC AUCTION REVENUES (EX AUCTIONS 5, 35) ($BIL.)[150]



Moreover, U.S. regulators have reversed course on liberalization. For the 700 MHz licenses, allocated UHF TV frequencies being abandoned by broadcasters with the analog switch-off (completed June 2009), the FCC conditioned different regulatory regimes. Licenses sold at auction were embedded with mandates to give priority to public safety communications traffic, or to provide "open access" for all wireless devices and applications. These licenses received sharply lower bids than licenses sold without such restrictions; indeed, the national "D" license, allocated 10 MHz, received no bid at or above the reserve price, such that the bandwidth continues to lie idle. The compatibility of old-style FCC micro-management with license auctions was theoretically clear, and well stated in Coase (1959). But benefits of market allocation are lost.

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[149] "To the industry's relief, FCC Chairman Michael Powell, with the blessing of Secretary of Commerce Donald Evans, recently halted a mandate from former President Clinton that would have required all government branches to identify suitable 3G spectrum by July 30 of this year and auction it off by September 2002." Lynette Luna, *Spectrum Quandary Puts 3G At Risk*, TELEPHONY ONLINE (July 23, 2001). See also, Patrick Ross, *Bush Wants to Delay Airwave Auction*, CNET NEWS.COM (April 9, 2001).

[150] Source: FCC (see Appendix 1). Auction 5 (PCS C) produced bids that largely went uncollected. Auction 35 (PCS C re-auction) bids went entirely uncollected.

Ironically, given their common normative roots, competitive bidding for licenses may undermine spectrum liberalization. By eliminating the rents awarded to new licensees, auctions tend to reduce the political demand for bandwidth supplements. Lacking more fundamental reforms in the system of spectrum allocation, license auctions may make the regulatory regime even more conservative.

a. Where's the Bandwidth?

This tension flows from the regulator's structurally passive role in spectrum allocation, coupled with the bi-level nature of the regulatory process. First, spectrum allocations are triggered by one or more interested parties formally requesting that the FCC accommodate new services. Second, if the FCC acts, entrants must then obtain licenses created in the allocation. There are risks of failure at either level; unless both the allocation and the license are obtained, the entrant wastes any investment in promoting regulatory change.[151]

Under the comparative hearing system, there was an implicit property right awarded to lobbyists for new allocations: if the Commission was persuaded to allocate spectrum for a new service, those who had petitioned the agency to achieve this policy would likely stand first in line, ahead of rival license applicants. With the switch to auctions, the queue is eliminated. The returns to innovation are thereby reduced. That part of the innovation that is specific to developing a new FCC allocation receives no payment. Competitors will free ride on the innovator's efforts, having equal standing in the auction.

License auctions are designed to eliminate wasteful rent seeking, a useful contribution. But they may simultaneously reduce incentives for productive rent seeking.[152] This lessens pressure for spectrum allocations. The strategy of liberalization, of which license auctions are a key component, may include offsets. The demonstration effect of market allocation of licenses may itself propel reforms that generally enable more bandwidth to be used by market participants. This may be observed in countries that have, in instituting auctions, jumped ahead to also reform the underlying allocation regime.[153]

In the U.S., however, weakened pressure for new allocations, combined with political arguments favoring revenue maximization, produced a spectrum drought, 1997-2006. The spectrum lags did not go unnoticed; Congress mandated additional auctions, using TV band spectrum, beginning in 2000. But the FCC, lobbied by incumbent carriers to delay new license

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[151] This scenario omits the possibility that the entrant seeks unlicensed spectrum, but can be easily extended to encompass unlicensed allocations, however, which sharply increased in the U.S. following the introduction of license auctions. This outcome was consistent with the rent seeking dynamics outlined here. As license rents were taxed away in competitively bid assignments, relative returns to rent seeking for unlicensed allocations increased. Rent seeking (or defending) activity by incumbents strategically intending to deter competitive entry via *licensed* spectrum buttresses the effect.

[152] The importance of rent seeking for the provision of valuable public goods was articulated in Dwight Lee, *In Defense of Excessive Government*, 65 SO ECON J 674 (1999).

[153] In addition to the statutory reforms instituted, 1989-1997, in Australia, New Zealand, Guatemala and El Salvador, the U.K. and Norway have promoted spectrum liberalization through regulatory agency actions in recent years. These policies attempt to allow private parties to bid for spectrum, not simply licenses allocated administratively on a case-by-case basis.

sales, postponed these auctions. The Bush Administration joined this *dirigiste* campaign in 2001. As Gerald Faulhaber wrote in 2006:

> The sorry result is that cellular companies are straining within their bandwidth restrictions and are unable to obtain new bandwidth to expand their business. Meanwhile, large amounts of bandwidth are currently occupied by VHF and UHF television broadcasters, even as the audience for broadcast-delivered TV shrinks…[154]

When the de facto ban on bandwidth was lifted, the Sept. 2006 auction of AWS licenses (allocated 90 MHz) and the March 2008 sale of 700 MHz licenses (allocated 52 MHz of UHF TV frequencies) sold to hungry spectrum consumers who spent lavishly. Some $33 billion in receipts was received by the U.S. Government – 62% of the total revenues collected from July 1994.

One consequence of the policy-imposed, decade-long spectrum drought period was a merger wave. In 2004, there were six major nationwide carriers: Verizon, Cingular, AT&T Wireless, Sprint, T-Mobile, and Nextel. In 2004-05, however, Cingular (a joint venture of SBC and BellSouth) acquired AT&T Wireless for $41 billion, while Sprint bought Nextel for $35 billion. When the dust settled, four national carriers remained. The two combinations were both driven, in large part, by a demand to access additional bandwidth; both networks launched 3G upgrades post-merger.[155] T-Mobile, which did not acquire additional significant spectrum during the drought period, had to delay its 3G services[156] until 2008, when its newly purchased bandwidth – it was the largest winning bidder in the AWS auction, spending $4.2 billion on licenses – enabled the roll-out of new high-speed data services with a network upgrade costing $2.7 billion.[157]

The current spectrum holdings of the four national carriers are seen in Figure 3. By aggregating licenses, network operators have assembled bandwidth blocks of consistent size (and, although not shown, frequencies). The relentlessness of market incentives masks a good deal of inefficiency. Thousands of secondary market transactions have contributed to these holdings, as have many FCC auctions. Firms have devoted much energy, not to mention tens of billions of dollars of investment capital, to acquiring these asset portfolios. Milgrom criticizes the laissez-faire attitude that initial assignments do not matter much, so long as the rights are "in the market."[158] It is a point worth making; institutions should be shaped to reduce such social

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[154] Faulhaber (2006), 262.

[155] "Cingular Wireless, the nation's largest cellphone service provider, announced plans yesterday to upgrade its high-speed data network, allowing faster downloads than are now available on many home broadband connections. The upgrade will start at the end of 2005, and the network will be in place nationwide by 2006, Cingular said. .. In October, Cingular Wireless closed its acquisition of AT&T Wireless, creating the nation's largest wireless company with 47 million subscribers. Cingular said the acquisition gave it the additional radio spectrum necessary to deploy the high-speed network." Matt Richtel, *Cingular to Upgrade Data Network*, NY TIMES (Dec. 1, 2004).

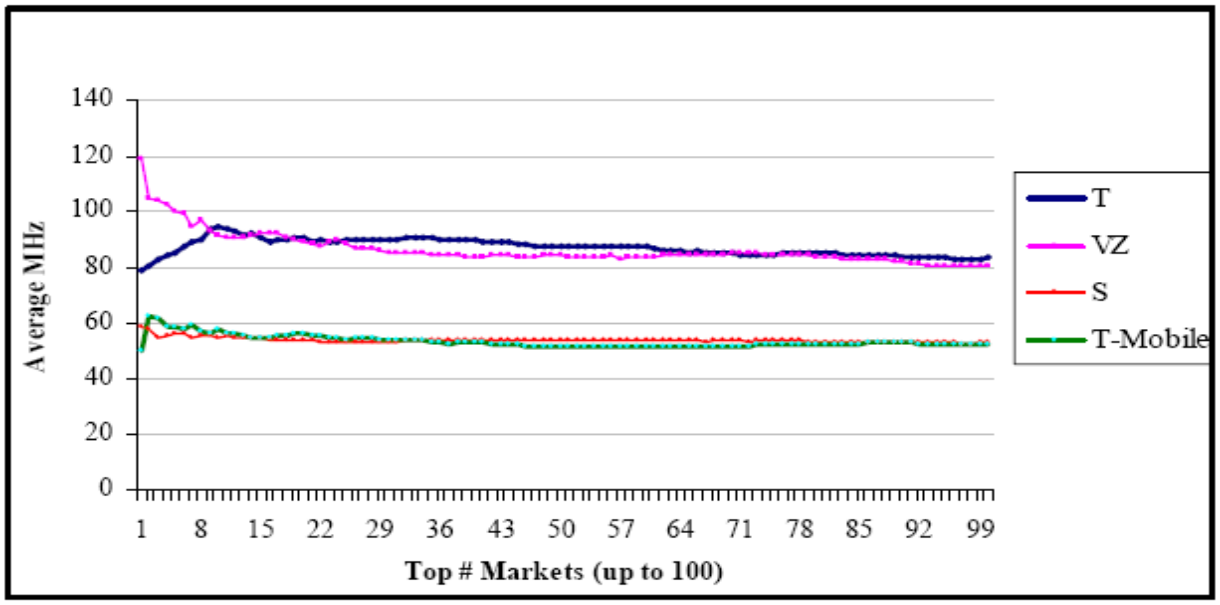
[156] "T-Mobile USA Inc. continues to lag behind its competitors in offering wide-area next-generation services, as the carrier is still working on deploying EDGE services. The carrier also has stated it will be at least two years before it has enough spectrum capacity to launch a UMTS-based network." Dan Meyer, *Verizon expands EV-DO, Cingular says it's under no pressure to match speed*, RCR WIRELESS NEWS (July 4, 2005).

[157] Laurie Sullivan, *T-Mobile Plans Major Cellular Upgrade To 3G*, INFORMATION WEEK (Oct. 16, 2006).

[158] Milgrom (2004), 19-21.

expense. But, again, Coasean symmetry is called for. If auctions tend to delay the release of additional bandwidth to market participants, gains from competitive bidding for licenses can be swamped by the costs of idle spectrum. The slow flow of spectrum during the license auction period in the U.S. is surely a cause for concern. The remedy is not in abandoning auctions, but in structural reforms that push the auction more deeply into the spectrum allocation function.

FIG. 3. DISTRIBUTION OF MOBILE CARRIER BANDWIDTH[159]



B. De-liberalization.

Driven both by an intellectual consensus among economists[160] and social demands to adopt more efficient license distributions,[161] U.S. spectrum allocation underwent a quiet but striking period of deregulatory reform, 1975-2000. During that time private satellites were authorized, cable TV operators were allowed to compete with broadcasters, content rules were relaxed for radio and TV stations, satellite TV and radio operators were licensed, and cellular and PCS licenses were issued. Spectrum policy was fundamentally altered in the liberalization of mobile licenses; initially, cellular operators were mandated to provide a particular service with a given (analog) technology, and the location of transmission facilities was fixed in the license.

By the time PCS permits were allocated in 1995, operators could select their own (digital) technology, provide voice, data, or video services, and had wide latitude in choice of business models. Disparate licenses – cellular, SMR, PCS – were unified under the CMRS (Commercial Mobile Radio Service) regime, allowing flexibility to licensees and promoting competition across otherwise disparate markets. The policy objective shifted from detailed

[159] Source: Blair Levin, *What 700 MHz Winners Can Do With Their Spectrum*, Stifel Nicolas (April 15, 2008), 4. T=AT&T; VZ=Verizon; S=Sprint.

[160] See Gregory L. Rosston et al., *Comments of 37 Concerned Economists*, Comment submitted to the Federal Communications Commission, WT Docket No. 00-230 (Feb. 7, 2001).

[161] For theoretical and empirical discussions of how spectrum policy has been reformed, see Hazlett (2001, 1998).

specification of technology, equipment, network architecture, and service, to an effort to "license spectrum."

Yet the traditional administrative system for allocating spectrum rights remained in place. And in recent years the political equilibrium at the FCC has retreated, slowing or reversing the path to liberal licenses. Important policies that resulted include the allocation of a 50 MHz "WiMax" band (3650-3700 MHz) for unlicensed rather than licensed use in 2005; the 700 MHz C block "open access" rules adopted in 2007; the 700 MHz D block "public safety" license plan adopted in 2007; and the TV band "white spaces" allocation for unlicensed devices (sharing the 294 MHz of "DTV spectrum") in 2008.

- *3650-3700 MHz*. A swath of 50 MHz adjacent to 3.5 GHz, the most popular international band for emerging WiMax services, was set aside for unlicensed devices in a 2005 Order. The FCC rejected a proposal from Intel and Alvarion (ironically, two of the largest manufacturing firms in the unlicensed device space) to largely allocate the bandwidth to liberal licenses. Instead, it issued non-exclusive use rights while requiring a registration system (to identify the location of transmissions) for users and mandating that operators adopt reasonable "contention-based protocols" to mitigate interference. This approach shifts the task of devising and regulating spectrum sharing etiquettes from profit-maximizing firms to the government.[162] As of mid-2009, the band supplied virtually no subscriber services.[163]

- *700 MHz C License "Open Access" Rules*. In crafting rules for the licenses to be auctioned in 2008 the FCC determined that the winner of the 22 MHz C license (the largest in the auction) would be obligated to provide non-discriminatory network access for all devices and applications.[164] This mandate leaves many details unanswered; it is not clear how far *prices* and *technologies* – as distinct from Acceptable Use Policies – may exclude devices or applications. Verizon won the C block, capturing a *60%*

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[162] Jerry Brito, *The Spectrum Commons in Theory and Practice*, STAN TECH L R (2007).

[163] Maravedis data from 2Q2009 registered 1,600 subscribers of wireless broadband services in the band, all of which were business customers. In contrast, 461,000 retail customers subscribed to Clearwire, offering service on licensed 2.5 GHz airwaves obtained in secondary market transactions from original licensees.

[164] The C Licensee is mandated by the FCC not to:

- Block, degrade, or interfere with the ability of end users to download and utilize applications of their choosing on the licensee's Block C network, subject to reasonable network management. Wireless service providers subject to this requirement will not be allowed to disable features or functionality in handsets where such action is not related to reasonable network management and protection, or compliance with applicable regulatory requirements. For example, providers may not "lock" handsets to prevent their transfer from one system to another.
- Block Wi-Fi access, MP3 playback ringtone capability, or other services that compete with wireless service providers' own offerings.
- Exclude applications or devices solely on the basis that such applications or devices would unreasonably increase bandwidth demands.
- Impose any additional discriminatory charges (one-time or recurring) or conditions on customers who seek to use devices or applications outside of those provided by the licensee.
- Deny access to a customer's device solely because that device makes use of other wireless spectrum bands, such as cellular or PCS spectrum.

Bingham Law firm summary (Aug. 15, 2007); http://www.bingham.com/Media.aspx?MediaID=5492.

discount attributed, in substantial measure, to the regulatory liability assumed.[165] If the discount resulted in superior retail market performance, it could well be justified. Yet, as seen in the current rivalry between RIM Blackberry, Apple iPhone, and Google gPhone, platform competitive business models locate across an "open–closed" continuum.[166] It is not the case that "open" access models invariably outperform; it is clearly the case that some "closed" platforms drive rivalry and deliver consumer benefits. Categorical restrictions by regulators diminish rivalry, tax the innovative process, and foreclose valuable options. This approach re-institutes the license rigidities of traditional spectrum regulation.

- *700 MHz D Block*. The FCC imposed expensive obligations on the 10 MHz D license, requiring the winning bidder to give priority access to public safety agencies (fire, police, emergency 'first responders') in a hybrid (commercial/public safety) wireless network. Extensive build-out obligations were also imposed, requiring network coverage of 75% of U.S. population by 2013, 95% by 2016 and 99.3% by 2019. No bid exceeded the reserve price of $1.3 billion. At the mean price/MHz-pop for A, B, C, and E licenses, D would have generated $3.9 billion. Instead, 10 MHz lies dormant.

In the 700 MHz license auction concluded in March 2008, the underlying spectrum was virtually identical across properties.[167] Yet price variances were very large. See Table 3. The C block sold for 29% of the adjusted price of the B block despite the aggregation premium on the larger-bandwidth C licenses. The C licenses, at B prices, would have cost Verizon nearly $16.6 billion -- $11.8 billion more. Of course, the D license did not sell, even at a reserve price one-third of the average obtained for the other licenses. This is evidence that regulatory rules and spectrum allocation procedures continue to distort markets. Bandwidth continues to be allocated not to where consumers desire it to be used, but where administrative mechanisms steer it.[168]

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[165] Verizon paid $4.7 billion for licenses allocated 22 MHz of nationwide spectrum; at the mean prices for the other comparable licenses sold in the auction (the A and B licenses also having paired spectrum) it would have paid $11.8 billion, or 2.5 times as much.

[166] Thomas W. Hazlett, *Modularity of Mobile Networks: Is the iPhone iPhony*? Paper presented at the Microsoft/GMU Conference on Innovation (May 7, 2009).

[167] Boundary conditions were a bit different. The A licenses were allocated spectrum adjacent to TV Channel 51, e.g., where digital television broadcasts would cause some conflicts in (relatively few) markets where such TV stations broadcast. Another difference was that the E license was offered as a single "block" and not as "paired" spectrum. This, however, reflects administrative discretion.

[168] In placing "open access" requirements on the C license, FCC policy makers effectively allocated spectrum for the benefit of application providers like Google that lobbied for the rules. By allowing such firms to direct resources without absorbing the costs of the resulting allocation, free rider problems emerge. See Sandro Brusco, Giuseppe Lopomo & Leslie Marx, *The 'Google Effect' in the FCC's 700 MHz Auction*, 21 INFORMATION ECONOMICS & POLICY 101 (2009).

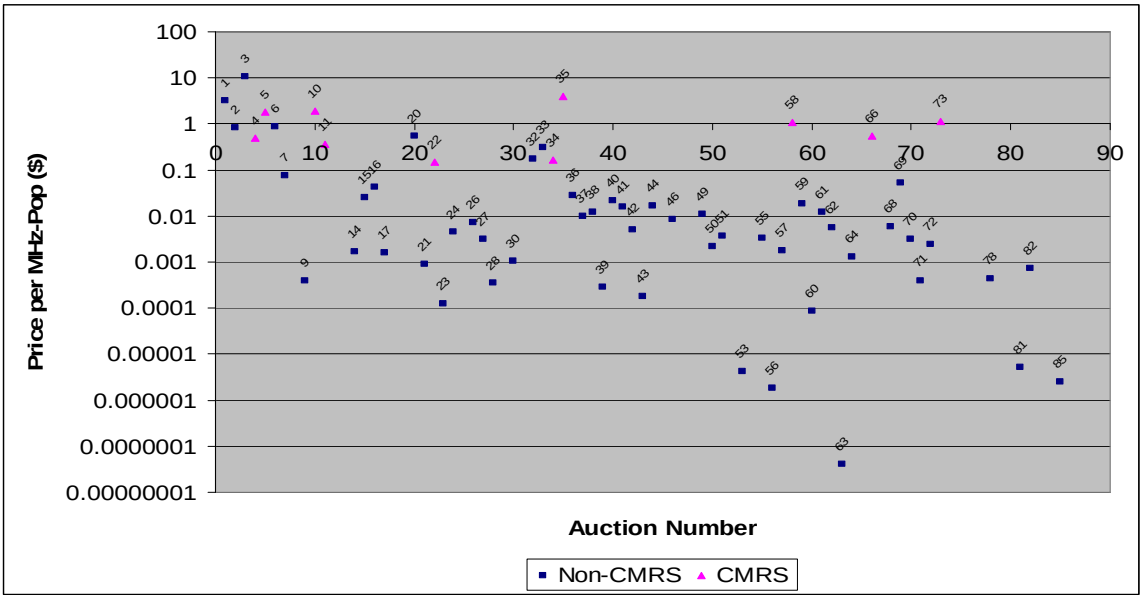
Table 3. Average Prices for Different Licenses in 700 MHz Auction (March 2008)

Block	*Net Winning Bids ($)*	*MHz * Pops*	*$/MHz/pop*
A	3,875,663,800	3,419,018,088	1.13
B	9,068,382,850	3,419,018,088	2.65
C	4,746,691,000	6,283,649,790	0.76
E	1,266,844,500	1,713,722,670	0.74
TOTAL	18,957,582,150	14,833,358,892	1.28

Source: Blair Levin, *Special Focus: The Wireless World After 700 MHz*, Stifel Nicolas (March, 2008), p. 4.

The degree to which the regulatory system distorts spectrum values is suggested in Figure 4, showing the price (adjusted for MHz and population in the licensed areas) paid across U.S. auctions divided by the mean price paid across all auctions.[169] CMRS licenses, embedding a (mostly) homogeneous set of licensee property rights, are denoted, and exhibit less variance than the non-CMRS sample. See also Table 4. Although economic factors, including overall market conditions and frequency location, alter bids over time, the extreme variance in FCC license prices is difficult to explain by changing economic circumstances alone. The distinct nature of the rights granted in different licenses, the manner in which spectrum is divvied up (or channelized), and the credits extended to certain auction participants have served to create large price variance.

FIG. 4. PRICE/MHZ/POP ACROSS U.S. LICENSE AUCTIONS, 1994-2008



[169] There have been 72 FCC auctions; the mean price per MHz-pop (equally weighted across auctions) is 23.17¢.

Table 4. FCC License Auction Prices: Means and Standard Deviations

	All Auctions	*CMRS Auctions*	*Non-CMRS Auctions*
Mean Price per MHz ($)	0.46	1.16	0.33
Std. Dev. ($)	1.51	1.19	1.54

Certain licenses have been embedded with broad, flexible spectrum use rights that permit licensees to determine services, business models, and technologies. In general, licenses used for mobile voice and data services have been liberally endowed.[170] The Coasean vision of functioning, efficient spectrum markets are thereby supported – and observed. Most spectrum, however, continues to be allocated in highly restrictive ways, either bottled up in little used government allocations or dedicated to traditional licenses granting sharply truncated spectrum property rights.

That regulators seek to promote different services with different licenses constitutes an industrial policy Gerald Faulhaber and David Farber dub "GOSPLAN."[171] Satellite radio licenses, for example, permit only national broadcasts; targeted, localized content is prohibited (to protect terrestrial radio stations). Satellite telephone operators are permitted to provide "ancillary terrestrial" mobile services only to augment satellite phone service, despite the fact that "land mobile" is likely to be the most efficient use of the band. Guard bands in 700 MHz frequencies have been heavily regulated, with licensees permitted only to operate on a common carriage model imposed by the Commission. The rules have proven unworkable, destroying the value of otherwise productive frequencies.[172]

License auctions appear to have exacerbated the tendency of spectrum misallocation under the regulatory regime, but the hypothesis is testable. The simpler point made here is that competitive bidding for licenses is easily compatible with a policy regime in which spectrum is allocated as state property. Absent more fundamental reforms, the "price system" will continue to be stymied in its effort to efficiently allocate radio spectrum.

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[170] Kwerel & Williams (2002).

[171] Faulhaber (2006), 265.

[172] Gregory L. Rosston, *The Long and Winding Road: The FCC Paves the Path With Good Intentions*, 27 TELECOM POL'Y 501 (Aug. 2003).

VI. CONCLUSION

When Ronald Coase began his investigation of the regulation of radio waves, the consensus view was that spillovers in the use of a resource disqualified markets as the efficient form of social organization. Only the unified control exerted by an administrative agency of the state could take into account the conflicts between rival users. Regulators, judges and industry experts agreed.

Coase wondered why the coordination commonly seen in market transactions would fail to obtain. Using the assumptions of prevailing economic models, he reasoned that they would not: if private actors were as perfectly informed as were government regulators, they would set ownership rules so as to maximize the value of output, sharing the gains. When the obscuring assumption of perfect information was relaxed, then the source of coordination problems became clear: ownership rights were not sufficiently established to permit the cooperation routinely exhibited elsewhere in the economy.

Coase (1959) is best known as an advocacy essay promoting FCC license auctions. Derided at first, the policy suggestion was eventually adopted in the U.S. by congressional statute in 1993. Competitive bidding commenced the following year, capturing about $52 billion in federal receipts in the years since. By rule of thumb, Coase's reform has generated at least $17 billion in efficiency gains (via reductions in tax distortions), placing him in the company of those rare scholars who can easily document the positive net social value of their research agenda.

Yet this seminal paper was actually not a polemic, and spectrum auctions not its principal legacy. What Coase fundamentally contributed was a symmetric analysis of property regime choices, explaining how the costs of the "price system" were real, but that so were the costs of any alternative. The administrative allocation system, by restricting productive activities, was also costly, and yet revealed none of the price information that would come from property owners pursuing gains from trade. Lacking such data, resource allocation would be an exercise in the dark.

Coase argued for analytical symmetry on logical grounds, and then expressed an expectation that private property would outperform state property given the rich empirical history of competing systems. He was open to correction; he, in fact, had little spectrum market evidence to distinguish the most efficient path. But the "invisible hand" generally worked. Why not here? He became convinced that the general case would obtain in the special case of radio spectrum when the arguments for administrative control were made. They were "incredibly feeble," and easily refuted by a law student who had fortuitously read Abba Lerner as an undergraduate.[173]

Thanks to changing technologies, evolving political equilibria, and the intellectual consensus that Coase fundamentally reshaped, policy makers around the globe have begun treating the spectrum allocated to mobile telecommunications licenses as de facto private

[173] Coase (1993), p. 249.

property. Decades of experience with comparative spectrum ownership institutions are now available for observation. The liberalization of private property rights has yielded extremely large social gains, permitting complex market structures to develop. No other form of spectrum allocation, including the "command and control" once thought necessary to avoid tragedy of the commons or the "spectrum commons" recently heralded as the obsolescence of Coasean property rights, supports such productive social coordination.

In this environment, new and interesting problems have appeared. Foremost among them is the apparent conflict between license auctions and efficiency in spectrum allocation. Where the price system is instituted to assign rights crafted under a non-market system, claimants bid competitively and rents are captured by the state. Rights assignments are more efficient, but dynamic pressure for the creation of new rights is reduced. Eliminating wasteful rent seeking, and the misallocations designed to attract it, saves society resources. But a good measure of *productive* rent seeking has been eliminated, as well. Spectrum policy makers may become less subject to pressures for market entry.

While market allocation of radio spectrum, tried and tested, generally out-performs administrative allocation, U.S. policy makers have remained in control of new spectrum allocations and may have become even more conservative. Consumers, innovators, and a host of industries visibly benefit from liberalization and would further gain from its extension. The rivalry between these competing political forces will yet determine whether the disruptive clarity of Ronald Coase will continue to drive spectrum property reforms to further frontiers of efficiency.

APPENDIX 1. FCC WIRELESS LICENSE AUCTIONS

No.	Auction Name	Auction Date	Length (Days)	Licenses Sold	Total Revenue (Net Bids - $)	Total MHz	Price per MHz-Pop
1	Nationwide Narrowband PCS	7/25/1994 - 7/29/1994	5	10	650,306,674	0.7875	3.158716
2	Interactive Video & Data Services	7/28/1994 - 7/29/1994	2	594	213,892,375	1	0.81816
3	Regional Narrowband PCS	10/26/1994 - 11/8/1994	9	130	392,706,797	0.45	10.68398
4	Broadband PCS A & B	12/5/1994 - 3/13/1995	60	99	7,721,184,171	60	0.487617
5	Broadband PCS C	12/18/1995 - 5/6/1996	83	493	10,071,708,842	30	1.260233
6	Multipoint/Multichannel Distr.Services	11/13/1995 - 3/28/1996	75	493	216,239,603	78	0.886594
7	900 MHz Specialized Mobile Radio	12/5/1995 - 4/15/1996	79	1020	204,267,144	10	0.077401
8	Direct Broadcast Satellite 110°	1/24/1996 - 1/25/1996	1.5	1	682,500,000	N/a	N/a
9	Direct Broadcast Satellite 148°	1/25/1996 - 1/26/1996	1.5	1	52,295,000	500	0.000393
10	Broadband PCS C (Re-auction)	7/3/1996 - 7/16/1996	8	18	904,607,467	30	0.11319
11	Broadband PCS D, E, F	8/29/1996 - 1/14/1997	85	1472(a)	2,517,439,565	30	0.312032
12	Cellular Unserved	1/13/1997 - 1/21/1997	6	14	1,842,533	N/a	N/a
14	Wireless Communications Service	4/15/1997 - 4/25/1997	9	126(b)	13,638,940	30	0.001691
15	Digital Audio Radio Service	4/1/1997 - 4/2/1997	2	2	173,234,888	25	0.025767
16	800 MHz Specialized Mobile Radio	10/28/1997 - 12/8/1997	27	524	96,232,060	10	0.035783
17	Local Multipoint Distribution System	2/18/1998 - 3/25/1998	26	864	578,663,029	1300	0.00164
18	220 MHz	9/15/1998 - 10/22/1998	26	693	21,650,301	N/a	N/a
20	VHF Public Coast	12/3/1998 - 12/14/1998	8	26(c)	7,459,200	0.05	0.549709
21	Location and Monitoring Service	2/23/1999 - 3/5/1999	9	289	3,438,294	14	0.000897
22	Block Broadband PCS C, D, E, F	3/23/1999 - 4/15/1999	17	302(d)	412,840,945	50	0.030153
23	LMDS Re-auction	4/27/1999 - 5/12/1999	12	161	45,064,450	1300	0.000127
24	220 MHz	6/8/1999 - 6-30-1999	17	222	1,924,950	1.55	0.004535
25	Closed Broadcast	9/28/1999 - 10/8/1999	9	115	57,820,350	N/a	N/a
27	Broadcast Auction	10/6/1999 - 10/8/1999	3	1	172,250	0.2	0.003145
26	929 & 931 MHz Paging Service	2/24/2000 - 3/2/2000	6	985	4,122,500	2	0.007324
28	Broadcast Auction	3/21/2000 - 3/24/2000	4	2	1,210,000	12	0.000358
30	39 GHz	4/12/2000 - 5/8/2000	19	2173	410,649,085	1400	0.001042
80	Blanco Texas Broadcast	7/12/2000 - 7/14/2000	3	1	18,798,000	N/a	N/a
33	Upper 700 MHz Guard Bands	9/6/2000 - 9/21/2000	12	96	519,892,575	6	0.307896
34	800 MHz SMR General Category	8/16/2000 - 9/1/2000	13	1030	319,451,810	1293.8	0.000877
36	800 MHz SMR Lower 80 Channels	11/1/2000 - 12/5/2000	22	2800	28,978,385	4	4.37
35	C & F Block Broadband PCS	12/12/2000 - 1/26/2001	24	422	16,857,046,150	70	0.845567
38	Upper 700 MHz Guard Bands (2001)	2/13/2001 - 2/21/2001	6	8	20,961,500	6	0.012267
39	VHF Public Coast Location Monitoring	6/6/2001 - 6/13/2001	6	217	1,144,755	14.05	0.000286
40	Paging	10/30/2001 - 12/5/2001	24	5323	12,897,127	2.12	0.021361
41	Narrowband PCS	10/3/2001 - 10/16/2001	8	317	8,285,036	1.8625	0.015619
42	Multiple Address Systems Spectrum	11/14/2001 - 11/27/2001	8	878(e)	1,202,725	0.825	0.005119
43	Mult-Radio Service	1/10/2002 - 1/17/2002	6	27(f)	1,548,225	30.5	0.000176
82	New Analog Television Stations	2/5/2002 - 2/13/2002	5	4	5,025,250	24	0.000726
44	Lower 700 MHz Band (2002)	8/27/2002 - 9/18/2002	16	484	88,651,630	18	0.017079
45	Cellular RSA	5/29/2002 - 6/4/2002	5	3	15,871,000	N/a	N/a
32	New AM Broadcast Stations	12/10/2002 - 12/12/2002	3	3	1,520,375	0.03	0.175744
46	1670-1675 MHz Nationwide License	4/30/2003	1	1	12,628,000	5	0.008685

48	Lower and Upper Paging Bands	5/13/2003 - 5/28/2003	11	2832	2,445,608	N/a	N/a
49	Lower 700 MHz Band (2003)	5/28/2003 - 6/13/2003	13	251	56,815,960	18	0.010854
54	Closed Broadcast (2003)	7/23/2003 - 7/29/2003	5	4	4,657,600	N/a	N/a
50	Narrowband PCS (2003)	9/24/2003 - 9/29/2003	4	48	428,709	0.6625	0.002225
51	Regional Narrowband (PCS) (2003)	9/24/2003 - 9/25/2003	2	5	134,250	0.125	0.003693
52	Direct Broadcast Satellite Service	7/14/2004	1	3	12,200,000	N/a	N/a
53	Multichannel Video Distribution & Data	1/14/2004 - 1/27/2004	9	192	118,721,835	96000	4.21E-06
55	900 MHz Specialized Mobile Radio	2/11/2004 - 2/25/2004	10	55	4,861,020	5	0.003311
56	24 GHz Service	7/28/2004	1	7	216,050	400	1.84E-06
57	Automated Maritime Telecom. System	9/15/2004	1	10	1,057,365	2	0.0018
37	FM Broadcast	11/3/2004 - 11/23/2004	14	258	147,876,075	51.6	0.009759
58	Broadband PCS (re-auction)	1/26/2005 - 2/15/2005	15	217	2,043,230,450	120	0.057444
59	Multiple Address Systems Spectrum	4/26/2005 - 5/18/2005	17	2223	3,865,515	0.7	0.01863
60	Lower 700 MHz Band	7/20/2005 - 7/26/2005	5	5	305,155	12	8.58E-05
61	Automated Maritime Telecom. System	8/3/2005 - 8/17/2005	11	10	7,094,350	2	0.011967
81	Low Power Television (LPTV)	9/14/2005 - 9/26/2005	9	90	834,600	540	5.21E-06
63	Multichannel Video Distribution & Data	12/7/2005	1	22	133,160	11000	4.08E-08
62	FM Broadcast (2006)	1/12/2006 - 1/31/2006	13	163	54,259,600	32.6	0.005559
64	Full Power TV Construction Permits	3/15/2006 - 3/20/2006	4	10	23,367,850	60	0.001301
65	800 MHz Air-Ground Radiotelephone	5/10/2006 - 6/2/2006	15	2	38,339,000	N/a	N/a
66	Advanced Wireless Services (AWS-1)	8/9/2006 - 9/18/2006	28	1087	13,700,267,150	90	0.508437
68	FM Broadcast (1/2007)	1/10/2007 - 1/17/2007	5	9	3,264,250	1.8	0.006012
69	1.4 GHz Bands	2/7/2007 - 3/8/2007	21	64	123,599,000	8	0.051223
70	FM Broadcast (3/2007)	3/7/2007 - 3/26/2007	14	111	21,301,175	22.2	0.003181
71	Broadband PCS (2007)	5/16/2007 - 5/21/2007	4	33	13,932,150	120	0.000385
72	220 MHz	6/20/2007 - 6/26/2007	5	76	185,416	0.25	0.002459
73	700 MHz Band	1/24/2008 - 3/18/2008	38	1090(g)	18,957,582,150	52	1.199004
77	Closed Cellular Unserved	6/17/2008	1	1	25,002	N/A	N/a
78	AWS-1 & Broadband PCS	8/13/2008 - 8/20/2008	6	53	21,276,850	165	0.000424
85	LPTV & TV Translator Digital Channels	11/5/2008 - 11/10/2008	4	30	134,725	180	2.46E-06
	Average auction length		**14.49**				
	Average Price per MHz-pop						**0.231747**
	Total Licenses			**27,484**			
	Total Winning Bids				**77,998,345,602**		
	Total Revenue Collected				**52,621,436,577**		
	Uncollected Revenue				**25,376,909,025**		
	Percent of High Bids Uncollected	**32.54**					

a) Data comes from Jeremy Bulow, Jonathan Levin, and Paul Milgrom. 2009 "Winning Play in Spectrum Auctions", National Bureau of Economic Research.