LAW AND ECONOMICS SEMINAR **Professor Polinsky**
Winter Quarter 2016

January 14, 2016
4:15 - 5:45 pm
Stanford Law School
Room 301

"The Anti-Commons Revisited"

by

Jonathan Barnett

(Gould School of Law, University of Southern California)

Note: It is expected that you will have reviewed the speaker's paper before the seminar. The author has provided the following guidance regarding the most important material to look at if you do not wish to read the entire paper:

"Critical sections (and the focus of my presentation): pp. 3-8 (abstract, introduction); pp. 9-15 (theoretical issues, can probably be skimmed by readers familiar with the literature); pp. 16-26 ("global" empirical evidence); pp. 26-32 (mini case study on auto market); and pp. 39-48 (detailed case study on aircraft market).

If you have additional time, you can proceed to read pp. 32-35 (mini case study on petroleum refining market), pp. 35-38 (mini case study on ICT markets); pp. 48-57 (detailed case study on early radio market); and pp. 57-66 (discussion of normative implications)."

Abstract:

Intellectual property scholars and policymakers often assert that technology and creative markets suffer from "anti-commons" ("AC") effects that restrain innovation within a web of conflicting intellectual property claims. A minority view asserts that market players have incentives and capacities to correct for AC effects through transactional solutions. To assess the relative merits of each side of this debate, I review a large and diverse body of empirical evidence relating to AC effects in contemporary and historical markets. I independently replicate the most controversial empirical findings, supplement additional research on selected markets, and provide a survey of all documented IP-pooling arrangements in U.S. markets since 1900. The weight of the evidence strongly favors the minority view. Evidence for AC effects is scarce while evidence that markets correct for AC effects is abundant. AC effects are typically preempted or mitigated through cooperative arrangements among small numbers of IP holders or transactional solutions devised by entrepreneurial intermediaries for large numbers of IP holders. This pattern recurs over a diverse array of markets and periods, including automobiles, petroleum refining, aircraft, and radio communications in the early to mid-20th century, and information and communications technology markets from the late 20th century through the present. Contrary to standard assumptions, there is little evidence that these markets experienced reduced or delayed innovation or output despite intensive levels of patent issuance and litigation.

Harvard Journal of Law & Technology
Volume 29, Number 1 Fall 2015

THE ANTI-COMMONS REVISITED

*Jonathan M. Barnett**

* Professor, University of Southern California, Gould School of Law. I am grateful for research assistance provided by Julia Damron, Joseph Gopez, Chris Gurchiek, and the library staff of the USC Gould School of Law. I benefited from comments by David Schwartz and participants in a workshop held at the Center for Technology, Innovation, and Competition at the University of Pennsylvania Law School. Further comments are welcome at jbarnett@law.usc.edu.

TABLE OF CONTENTS

I. INTRODUCTION

Scholarly and popular commentators on intellectual property ("IP") often assert that the U.S. innovation system provides excessively strong or numerous IP rights that drown innovation in a "thicket" or "anti-commons" of overlapping legal rights. The normative implication is some reduction in the strength and number of IP rights — a recommendation consistent with 2011 reforms to the Patent Act,[1] a string of patent-skeptical decisions by the Supreme Court,[2] and bills pending before Congress.[3] To date, academic and policy discussion of

1. In 2011, Congress passed the America Invents Act, which expands opportunities for contesting patents and provides a prior user defense against patent infringement. *See* Leahy-Smith America Invents Act, 35 U.S.C. §§ 112–129 (2011).

2. *See, e.g.*, Alice Corp. Pty. Ltd. v. CLS Bank Int'l, 134 S. Ct. 2347, 2358–60 (2014) (denying patentability of certain financial-method patents even if implemented on a computer); Ass'n for Molecular Pathology v. Myriad Genetics, 133 S. Ct. 2107, 2111 (2013) (denying patentability of certain isolated genetic sequences); Quanta Computer v. LG Elec., 553 U.S. 617, 621 (2008) (upholding patent exhaustion doctrine); KSR Int'l v. Teleflex, Inc., 550 U.S. 398, 427–28 (2007) (relaxing standard for finding a patent to be invalid as nonobvious); Medimmune v. Genentech, Inc., 549 U.S. 118, 118–19 (2007) (expanding circumstances under which patent licensee may seek declaratory judgment that the licensed patent is invalid); eBay v. MercExchange, LLC, 547 U.S. 388, 390 (2006) (holding that even if patent is found valid and infringed, injunctive relief only follows subject to traditional four-factor test).

3. *See generally* Innovation Act, H.R. 9, 114th Cong. (2015) (setting forth changes to pleading standards, fee shifting, and discovery procedures); Patent Transparency and Improvements Act, S. 1720, 113th Cong. (2013) (setting forth changes involving fee shifting and demand letters).

the "anti-commons" ("AC") thesis has relied primarily on theoretical argument and limited anecdotal evidence. A majority view holds that AC effects are a common occurrence that raises significant policy concerns about excessive IP rights.[4] A minority school of thought is more optimistic and argues that markets have strong capacities to resolve AC effects through contract and other mechanisms.[5] The majority view appears to be consistent with widely publicized "patent wars" in the global smartphone market and has been adopted in some notable policymaking venues. Prominent reports by government agencies and other influential bodies often suggest, or flatly assume, that the AC thesis describes a risk that has been, or is highly likely to be, realized.[6] A recent court decision that limited the patentability of genetic material and medical diagnostic innovations mentioned AC concerns as a supporting factor.[7]

Discussion of IP thickets among academic and policy commentators has so far proceeded without any comprehensive analysis of the substantial but dispersed body of evidence that relates to the AC thesis.[8] In this Article, I aggregate and critically review that diverse body

4. For the leading sources, see generally MICHAEL A. HELLER, THE GRIDLOCK ECONOMY: HOW TOO MUCH OWNERSHIP WRECKS MARKETS, STOPS INNOVATION, AND COSTS LIVES (2008); Michael A. Heller & Rebecca S. Eisenberg, *Can Patents Deter Innovation? The Anticommons in Biomedical Research*, 280 SCIENCE 698 (1998). Similar views are expressed by LAWRENCE LESSIG, THE FUTURE OF IDEAS: THE FATE OF THE COMMONS IN A CONNECTED WORLD (2003); ADAM JAFFE & JOSH LERNER, INNOVATION AND ITS DISCONTENTS (2004); JAMES BESSEN & MICHAEL J. MEURER, PATENT FAILURE: HOW JUDGES, BUREAUCRATS AND LAWYERS PUT INNOVATORS AT RISK (2008); MICHELE BOLDRIN & DAVID LEVINE, AGAINST INTELLECTUAL MONOPOLY (2008); James Boyle, *The Second Enclosure Movement and the Construction of the Public Domain*, 66 L. & CONTEMP. PROBS. 33 (2003); Paul A. David, *Mitigating "Anticommons" Harms to Science and Technology Research*, 2 WIPO J. 59 (2010).

5. For the leading sources, see generally Robert P. Merges, *Contracting into Liability Rules: Intellectual Property Rights and Collective Rights Organizations*, 84 CALIF. L. REV. 1293 (1996) [hereinafter Merges, *Contracting into Liability Rules*]; Robert P. Merges, *Institutions for Intellectual Property Transactions: The Case of Patent Pools*, *in* EXPANDING THE BOUNDARIES OF INTELLECTUAL PROPERTY: INNOVATION POLICY FOR THE KNOWLEDGE SOCIETY (Rochelle C. Dreyfuss et al. eds., 1998).

6. *See, e.g.*, FED. TRADE COMM'N, THE EVOLVING IP MARKETPLACE: ALIGNING PATENT NOTICE AND REMEDIES WITH COMPETITION 56 (2011); FED. TRADE COMM'N, TO PROMOTE INNOVATION: THE PROPER BALANCE OF COMPETITION AND PATENT LAW AND POLICY 9–10 (2002) [hereinafter FTC REPORT]; TIMOTHY J. MURIS, CHAIRMAN, FED. TRADE COMM'N, COMPETITION AND INTELLECTUAL PROPERTY POLICY: THE WAY AHEAD (Nov. 15, 2001), https://www.ftc.gov/public-statements/2001/11/competition-and-intellectual-property-policy-way-ahead [https://perma.cc/3RM2-FXAB].

7. Ass'n for Molecular Pathology v. U.S. Patent & Trademark Office, 702 F. Supp. 2d 181, 208 (S.D.N.Y. 2010). In a recent decision by the Federal Circuit, a dissenting judge observed that there is little to no empirical evidence for the anti-commons thesis. *See* Momenta Pharm., Inc. v. Amphastar Pharm., Inc., 686 F.3d 1348, 1374–75 (Fed. Cir. 2012) (Rader, J., dissenting).

8. Charles McManis and Brian Yagi provide an excellent review of empirical studies of the AC thesis with respect to contemporary scientific research. *See generally* Charles R. McManis & Brian Yagi, *The Bayh-Dole Act and the Anticommons Hypothesis: Round Three*, 21 GEO. MASON. L. REV. 1049 (2014). This paper covers a broader body of evidence relating to AC effects in contemporary and historical technology and content markets.

of evidence, independently replicating some of the most controversial results, surveying over a century's worth of pooling arrangements, and providing additional evidence on potential AC effects in certain markets. Two surprising and unusually consistent conclusions emerge. First, there is little concrete evidence that intensive levels of IP acquisition and enforcement restrain innovation or output. Second, unless constrained by antitrust or other limitations on contractual enforcement, markets consistently exhibit capacities to devise transactional solutions that preempt or mitigate IP thickets. These conclusions erode confidence in the majority view, and in turn casts doubt on normative recommendations that favor weakening IP rights to preclude AC effects.

My analysis proceeds in two steps. First, I revisit the theoretical arguments behind the standard formulation of the AC thesis. Closer scrutiny shows that these arguments overestimate the likelihood of persistent AC effects. The reason derives from simple Coasean logic.[9] Any market that suffers from AC effects is leaving money on the table by suppressing profitable IP-related transactions. Profit-seeking parties therefore have incentives to devise transactional solutions to resolve AC effects and capture some portion of those suppressed gains. IP holders are likely to independently reach a mutually agreeable arrangement in low-transaction-cost settings where holders are few in number and hold comparably valued IP assets. Even in higher-transaction-cost settings where IP holders are great in number or do not hold comparably valued IP assets, third-party intermediaries have incentives to develop mechanisms that relieve deadlock and generate the resulting gains. Hence, even if AC effects are likely to arise, they are unlikely to persist in any market that enjoys a reliable infrastructure for enforcing contractual commitments.

Second, I review three bodies of evidence relating to the AC thesis. All support the view that markets are likely to anticipate and correct for AC effects.

A. Contemporary Evidence

Contemporary U.S. technology markets have operated for several decades under historically intensive levels of patent acquisition and enforcement. If AC effects were a serious concern, we should expect to find evidence that innovation has slowed during this period. Precisely the opposite is the case. From 1982, which marks the establishment of the Federal Circuit and the start of widely-recognized

9. *See generally* Ronald H. Coase, *The Problem of Social Cost*, 3 J. L. & ECON. 1 (1960). The "Coase theorem" holds that parties will bargain toward economically efficient resource allocations, irrespective of the initial allocation of property rights.

increases in patent applications, grants, and litigation filings,[10] through 2011, industry expenditures on research and development ("R&D") as a percentage of gross domestic product (a widely used proxy for innovation activity) have moved within a narrow range bounded by 1.2% in 1982, hitting a high of almost 1.8% in 2000, and, despite the effects of the financial crisis, still ending just slightly below 1.6% in 2011.[11] If we look specifically at fields in which the AC thesis has been most frequently asserted — namely, the consumer electronics, biopharmaceutical,[12] and software markets — the trends in innovation are even rosier and rosiest of all in the jurisdiction in which patent protection is perceived to be most robust, namely the United States.[13] In particular, I review multiple leading studies that

10. *See* John L. Turner, *In Defense of the Patent Friendly Court Hypothesis: Theory and Evidence* (Dep't of Econ., Terry Coll. of Bus., Univ. of Ga., Working Paper, 2004) (based on data from 1953–2002, finding sharp growth in U.S. patent applications and patent litigation following establishment of the Federal Circuit in 1982); Jonathan M. Barnett, *Dynamic Analysis of Intellectual Property: Theory, Evidence & Policy*, 37 fig.V (Univ. of So. Cal. Sch. of Law Working Paper, 2013) (based on USPTO data from 1860–2011, showing a sharp increase in domestic patent applications and grants since the 1980s, adjusted for population growth); Brian Howard, *Patent Case Trends and the Business of Litigation*, LEX MACHINA (Feb. 5, 2015), https://lexmachina.com/patent-case-trends-business-litigation [https://perma.cc/3WG5-P2RJ] (for 2007–2014, showing increase in patent litigation filings from 2007 and then slight decrease since 2013).

11. Author's calculations, based on government data. More specifically, I calculated the following industry-funded R&D/GDP ratios as follows: (1) 1.2% (1982); (2) 1.31% (1985); (3) 1.36% (1990); (4) 1.42% (1995); (5) 1.78% (2000); (6) 1.56% (2005); (7) 1.64% (2010); (8) 1.58% (2011). For industry-funded R&D from 1953–2011, see NAT'L SCIENCE FOUND., U.S. RESEARCH AND DEVELOPMENT EXPENDITURES 4-9 fig.4-1 (2014). For historical GDP data, see BUREAU OF ECON. ANALYSIS, CURRENT-DOLLAR AND "REAL" GROSS DOMESTIC PRODUCT (2015) http://www.bea.gov/newsreleases/national/gdp/2015/gdp1q15_adv.htm [http://perma.cc/KAU3-5XD7]. While trends in the industry R&D/GDP ratio certainly reflect in part the influence of multiple other environmental factors, they suggest at a minimum that there has not been any significant decline in U.S. innovative performance over several decades of intensive patent grants and litigation.

12. For patent thicket claims with respect to all of these industries, see Carl Shapiro, *Navigating the Patent Thicket: Cross Licenses, Patent Pools and Standard Setting*, 1 INNOVATION POL'Y & ECON. 119, 119 (2001). For the same claims with respect specifically to software, see LESSIG, *supra* note 4, at 205–15. For biopharmaceutical research, see generally Heller & Eisenberg, *supra* note 4.

13. *See* Iain Cockburn et al., *Pharmaceuticals and Biotechnology*, *in* U.S. INDUSTRY IN 2000: STUDIES IN COMPETITIVE PERFORMANCE 363, 391 (Nat'l Research Council ed., 1999) (noting lack of adequate patent protection for biotechnology in Europe, as compared to the U.S.); Rosemarie Ziedonis, *Intellectual Property and Innovation*, *in* THE HANDBOOK OF TECHNOLOGY AND INNOVATION MANAGEMENT 295, 303 (Scott Shane ed., 2008) (noting stronger protection for software algorithms in the United States as compared to Europe). I note that patent protection for certain biotechnology innovations and software programs under U.S. law is now potentially weaker in light of Supreme Court decisions in 2013 and 2014, respectively. *See supra* note 2. On doubts regarding the existence of a patent thicket in the electronics industry, see *infra* Part III.C.3. On doubts regarding the existence of a patent thicket in biotechnology, see generally David E. Adelman & Kathryn L. DeAngelis, *Patent Metrics: The Mismeasure of Innovation in the Biotech Patent Debate*, 85 TEX. L. REV. 1677 (2007); and Timothy Caulfield et al., *Evidence and Anecdotes: An Analysis of Human Gene Patenting Controversies*, 24 NAT. BIOTECH. 1091, 1093 (2006). On doubts regarding the existence of a patent thicket in the software industry, see generally Ronald J.

have sought to identify AC effects in biomedical and related scientific research, virtually all of which have found little evidence of such effects.[14]

B. Historical Evidence

Technology markets characterized by intensive patent acquisition and enforcement conform to a virtually unfailing historical norm. A survey of over 100 years of documented IP pooling and cross-licensing arrangements shows that, unless constrained by antitrust limitations, IP holders or third-party intermediaries regularly devise mechanisms to avoid deadlock. A closer review of particular historical cases bolsters this view. In automobiles and petroleum refining in the early to mid-20th century and information technology markets in the late 20th century through the present, constituencies that are vulnerable to AC effects have repeatedly taken preemptive action by devising various licensing and other IP-sharing arrangements.[15] Contrary to standard expectations, there is little to no evidence that output or innovation declined in those markets even during the most intensive periods of IP litigation.

C. Revisiting the "Easy" Cases

I review and independently replicate recent studies by John Howells and Ron Katznelson ("H&K") of two historical cases that are commonly referenced in support of the AC thesis: (1) the Wright brothers' patents on aircraft technology and (2) early patents in radio communications technology.[16] My review largely confirms H&K's findings that there is little ground in both cases to support the view that patent-related disputes significantly restrained innovation, or that government intervention was necessary to resolve patent deadlock. The reason is just as a nuanced understanding of the AC thesis pre-

---

Mann, *The Myth of the Software Patent Thicket: An Empirical Investigation of the Relationship Between Intellectual Property and Innovation in Software Firms* (Univ. of Tex. Sch. of Law Working Paper No. 44, 1994). *But see* Stuart J.H. Graham & David C. Mowery, *Software Patents: Good News or Bad News?*, *in* INTELLECTUAL PROPERTY RIGHTS IN FRONTIER INDUSTRIES: SOFTWARE AND BIOTECHNOLOGY 45, 73 (Robert W. Hahn ed., 2005); Robert P. Merges, *Software and Patent Scope: A Report from the Middle Innings*, 85 TEX. L. REV. 1627, 1628 (2007).

14. *See infra* Part III.A.2.

15. *See infra* Part III.C.

16. *See generally* Ron D. Katznelson & John Howells, *The Myth of the Early Aviation Patent Hold-Up—How a U.S. Government Monopsony Commandeered Pioneer Airplane Patents*, 24 IND. CORP. CHANGE (2014) [hereinafter Howells & Katznelson, *Early Aviation*]; John Howells & Ron D. Katznelson, The Coordination of Independently-Owned Vacuum Tube Patents in the Early Radio Alleged Patent "Thicket" (June 2014) (unpublished manuscript), http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2450025 [http://perma.cc/Y3CZ-BRNL] [hereinafter Howells & Katznelson, Early Radio].

dicts: concerned parties have incentives to reach agreements to resolve disputes and enjoy the resulting gains.

Viewed as a whole, the accumulated body of evidence provides little ground to believe that AC effects typically persist in IP-intensive markets or cause any significant adverse effect to innovation. The AC thesis thus reduces to a modest proposition that IP-intensive markets are inherently at risk of AC effects, although these effects usually remain unrealized. These findings demand a rethinking of the normative propositions the AC thesis is typically used to support.

In particular, the paucity of empirical evidence to support the AC thesis reduces confidence in proposals to weaken IP rights in order to protect the market from AC effects. Conversely, the abundance of empirical evidence for markets' self-corrective capacities raises confidence that robust IP protection carries little threat of deadlock. While IP-pooling arrangements[17] inherently carry the risk of facilitating direct or indirect forms of collusion with respect to price or output, this potential side-effect can be addressed through surgical applications of antitrust law that impose de facto design requirements for pools and similar arrangements. Modern antitrust guidelines have established a template for pool design that reduces the collusion risk inherent in cross-licensing arrangements. When implemented in conformity with those guidelines, these arrangements not only prevent IP deadlock but also facilitate IP dissemination that would otherwise be infeasible, thus providing a boost to innovation while minimizing collusion risk.[18] In the best case, markets enjoy a "win-win" result, avoiding the transactional losses typically attributed to patents while using patents to unlock transactional gains that would otherwise be suppressed.

This paper is organized as follows. In Part II, I revisit the theoretical underpinnings of the AC thesis. In Part III, I review contemporary and historical evidence relating to the AC thesis, including case studies of selected markets. In Part IV, I review H&K's studies of alleged AC effects in the early aircraft and radio communications industries. In Part V, I analyze the antitrust risks inherent to cross-licensing and pooling arrangements and the policy tools available to minimize those risks.

---

17. As used in this Article, a "pooling arrangement" refers to any contractual or other arrangement by which three or more entities contribute patents to a common pool, to which each licensor and other non-contributing licensees have access subject to an agreed-upon royalty rate and other terms.

18. Modern pooling entities rely on the guidance set forth in antitrust agencies' guidelines on intellectual property licensing and, in some cases, business review letters. *See infra* note 78. The business review letter process is a statutory procedure by which parties to a proposed transaction can request an indication from the Antitrust Division of the Department of Justice as to whether the Department currently intends to take action on antitrust grounds against the transaction if consummated. *See infra* Part V.C.1.

II. THE ANTI-COMMONS EFFECT: A THEORETICAL ASSESSMENT

The AC thesis describes a situation where the state issues excessive numbers of, or overly fragmented, property rights. As a result, investment is discouraged by dispute resolution, negotiation, and other transaction costs. The thesis was initially set forth by Professor Michael Heller with respect to post-Communist transition economies,[19] but Heller and other scholars have extended it to IP rights.[20] Scholars argue that AC effects impeded innovation in historical settings such as automobiles, radio communications, and aircraft[21] and are impeding innovation in contemporary settings such as scientific research and biotechnology, semiconductors, software, and the Internet.[22] In the case of intangible goods, commentators frequently state or assume that AC effects are likely to arise in markets consisting of products comprising multiple components covered by IP rights that are held by multiple parties.[23]

The AC thesis posits two possible social harms from excessive issuance of property rights. First, rights holders may be caught in a transaction-cost impasse that slows down innovation or commercialization by preventing a single entity from assembling all the components required to make a particular product. For example, an original equipment manufacturer such as Dell may be unable to assemble a laptop computer if it cannot obtain patent licenses to each of the components required to assemble that product. Second, rights holders may engage in individually rational, but collectively destructive, pricing behavior that limits or blocks the otherwise efficient production of technological or creative goods. Known as "royalty stacking," this is the familiar double marginalization problem applied to the IP con-

---

19. *See* Michael A. Heller, *The Tragedy of the Anticommons: Property in the Transition from Marx to Markets*, 111 HARV. L. REV. 621, 622 (1998).

20. *See, e.g.*, HELLER, *supra* note 4, at 4–6, 49–63; Heller & Eisenberg, *supra* note 4, at 698. As of September 30, 2015, Google Scholar indicated that the Heller and Eisenberg paper has been cited 2485 times. *See* GOOGLE SCHOLAR, https://scholar.google.com [http://perma.cc/XDA7-U426] (search for "Heller and Eisenberg, Can Patents Deter Innovation? The Anticommons in Biomedical Research" and view citation reference).

21. For these types of arguments with respect to automobiles, see *infra* note 85. With respect to aircraft, see *infra* notes 196–198 and accompanying text. With respect to radio communications, see *infra* notes 242–243 and accompanying text.

22. For these types of arguments with respect to scientific research and biotechnology, see Heller & Eisenberg, *supra* note 4. With respect to software, see generally LESSIG, *supra* note 4; Shapiro, *supra* note 12. With respect to semiconductors and the Internet, see Shapiro, *supra* note 12, at 119.

23. *See, e.g.*, Shapiro, *supra* note 12, at 119, 122 (asserting that "[i]n several key industries, including semiconductors, biotechnology, computer software and the Internet, our patent system is creating a patent thicket" but basing that assertion on a handful of anecdotal examples, treating it as an assumption).

text.[24] If each patentee demands an individually profit-maximizing royalty with respect to its component, meaning it does not take into account the pricing behavior of other patentees, the collective royalty burden may be set at inefficiently high levels, thereby restraining innovation, production, and distribution of the end-product that embodies those components. To continue the previous example, Dell may find that it cannot sell laptops at a profit given the collective royalty burden it must pay to upstream patent licensors. The result could be a degraded market characterized by laptops with limited functionality, highly priced laptops that few consumers can afford, or no laptops at all.

Both social harms derive from a single source: transaction costs are so high that production of a multi-component technological or creative product cannot proceed or can only do so under inefficiently high pricing. The result is a classic market failure consisting of higher prices and reduced output. However, as explained below, closer examination shows that this unfortunate result is only likely to hold true in specialized circumstances. In all other circumstances, AC effects are unlikely to arise or persist. The reason behind this counter-argument is straightforward: IP rights holders have incentives and capacities to negotiate cooperative arrangements that generate surplus value that would otherwise remain suppressed.

A. Numbers and Endowments

In its simplest formulation, the AC thesis asserts that deadlock is likely to arise in any market involving technologies consisting of multiple components covered by a dispersed set of IP rights. That proposition is too crude. The likelihood of deadlock will primarily vary depending on the number of holders of IP rights and the relative value of each holder's IP assets (what I will call "endowment"). Hence, even if AC effects are a universal risk in IP-governed markets, the magnitude and likelihood of that risk will vary across markets.

More specifically, deadlock will be least likely in settings involving few holders with comparably-valued endowments, who will face few barriers to coordinating with one another to transact for IP rights. As one or both of those variables increases in value, deadlock becomes more likely due to the additional transaction costs imposed by

24. Double marginalization refers to a scenario in which multiple suppliers of necessary inputs exert market power at different points on a supply chain. Absent coordination, the suppliers collectively generate aggregate pricing levels that inefficiently restrict output and reduce collective profits. For a modern discussion, see generally Carl Shapiro, *Theories of Oligopoly Behavior*, *in* HANDBOOK OF INDUSTRIAL ORGANIZATION 330–414 (Richard Schmalansee & Robert Willigs eds., 1989). For applications to the IP context under the "royalty stacking" rubric, see Heller & Eisenberg, *supra* note 4 at 699–700; Mark A. Lemley & Carl Shapiro, *Patent Holdup and Royalty Stacking*, 85 TEX. L. REV. 1991 (2007).

a greater number of participants bargaining with differently valued IP endowments. Using Figure 1 below for illustrative purposes, AC effects are most likely to arise and persist in the region above the curve while less likely to do so in the region below the curve.

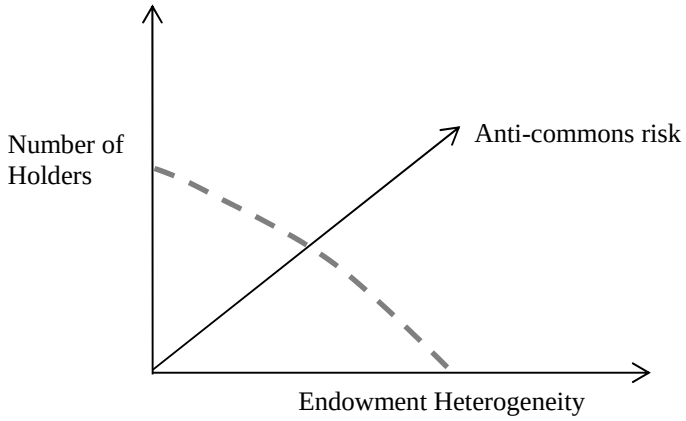

Figure 1: Anti-Commons Risk

1. Numbers

Transaction costs rise as the number of holders increases. In large-numbers environments, two related factors increase the likelihood of an AC outcome. First, large numbers increase the transaction costs of identifying IP rights holders and communicating with and securing agreement among them. As numbers increase, so too does the risk of an unknown rights holder who opportunistically waits for other holders to commit to, and make investments in, a particular technology. That party can then "hold out" for a special premium in exchange for not depleting the value of those technology-specific investments through infringement litigation.[25] In a handful of litigations, parties have alleged that patent holders failed to disclose patented technology "essential" to a technical standard being formulated by a

25. As used in the economics and law-and-economics literatures, "hold-up" refers to any case in which (1) one party has made an irrevocable investment in an asset that is "specific" to a particular transaction and (2) another party takes advantage of that fact in order to demand a change in the terms of the transaction. Absent repeat-play deterrents against opportunistic behavior, the non-investing party can extract the entire value of the other party's relationship-specific investment. For the classic treatment, see Oliver E. Williamson, *Transaction-Cost Economics: The Governance of Contractual Relations*, 22 J.L. & ECON. 233, 241–42 (1979).

standard-setting organization[26] and subsequently filed patent infringement lawsuits against firms that had developed products based on the standard.[27] Second, depending on the distribution of the collective IP portfolio and associated revenue streams among the concerned population of IP rights holders, it may be the case that no rights holder has an individually rational incentive to incur the transaction costs required to reach a collectively rational agreement among all parties. If IP rights are sufficiently small and dispersed, it is possible that collective gains would be left unrealized, given the transaction costs required to aggregate IP rights and enable investment in the associated set of technological or creative innovations.

2. Endowment Values

Endowment values refer to the economic value of the IP assets held by a particular party.[28] Endowment values matter because parties with comparably valued IP endowments can more easily engage in exchanges that operate to each other's mutual benefit. When parties hold differently valued IP endowments, transaction costs rise since the party with the higher value endowment will demand cash or other in-kind transfer payments to render the proposed asset exchange reciprocal in value.[29] Such transactions require evaluating precisely the difference between the value of the parties' respective IP assets and negotiating side payments to reconcile any such difference. This is a nontrivial task in IP markets that typically lack any agreed-upon valuation standard akin to liquid product markets, in part due to the fact that the terms of licensing agreements are usually private and IP assets tend to be idiosyncratic.[30] When endowments are perceived to be comparable in value, this transactional step can be omitted, thereby

26. Standard-setting organizations, commonly known as "SSOs," are typically administered by representatives of large global technology firms, who agree upon common technical standards for new technologies but require that all participating firms disclose all "essential" patents and agree to license those patents on a "reasonable and non-discriminatory" basis.

27. *See* Joel M. Wallace, Rambus v. F.T.C. *in the Context of Standard-Setting Organizations, Antitrust, and the Patent Hold-Up Problem*, 24 BERK. TECH. L.J. 661, 661 (2009).

28. As is appropriate in a market environment populated by profit-seeking entities, I assume that "economic value" is a reasonably complete approximation of the value attributed to an IP asset by any individual holder. As Heller and Eisenberg observe, public institutions may have non-market interests. Heller & Eisenberg, *supra* note 4, at 700. In that case, the argument above would still hold but "endowment value" would be understood to encompass a broader range of economic and non-economic values.

29. For an acknowledgement of this point, see *id*.

30. *See* Martha Amram, *The Challenge of Valuing Patents and Early-Stage Technologies*, 17 J. APPLIED CORP. FIN 68, 68. In the semiconductor industry, firms sometimes use patent counts as a crude measure of value in cross-licensing negotiations due to the difficulty of evaluating individual patents. *See* Brownyn H. Hall & Rosemarie Ham Ziedonis, *The Patent Paradox Revisited: An Empirical Study of Patenting in the U.S. Semiconductor Industry, 1979-95*, 32 RAND J. ECON. 101, 110 (2001).

lowering negotiation costs and increasing the likelihood of reaching a mutually beneficial resolution to the IP deadlock.

The semiconductor industry nicely illustrates these considerations. From the post-World War II period until the 1980s, U.S. semiconductor manufacturers typically followed industry norms favoring below-market, nominal or zero-royalty cross-licensing of IP assets.[31] This apparently altruistic practice (which, as I discuss subsequently, emerged concurrently in the automotive industry)[32] reflected a business rationale. Since firms anticipated that a full-blown diligence and negotiation process in any particular exchange would result on average in negligible net payments being owed, the firms tolerated certain levels of knowledge sharing but avoided the transactional burden inherent to a fully negotiated and formalized evaluation and rate-calculation process. That burden can be considerable: one source indicates that thorough negotiation of a customized patent license in the semiconductor industry can take up to a year.[33] But these transaction-cost considerations no longer prevail once value differences between IP holders become sufficiently large. For this reason, the nominal-royalty and zero-royalty norms that had prevailed in the semiconductor industry faltered once Japanese and later Korean firms, who had no comparable patent portfolios to place on the table, entered the semiconductor market in the 1980s. As a result, U.S. firms, led by Texas Instruments, adopted licensing models, supported by litigation threats, that necessitated more precise evaluation of the relative values of parties' patent holdings, with appropriate modifications to net royalty rates.[34]

B. Small-Number and Large-Number Solutions

The same bargaining logic that identifies an increased likelihood of AC effects in large-number, heterogeneous-endowment settings (designated as Scenario Two in Figure 2 below) identifies two scenarios in which there is a reduced likelihood that the AC thesis will be realized or, if realized, that it will persist. Scenario One contemplates a small number of IP holders with homogeneous endowments who successfully agree upon a cooperative arrangement to quell infringement litigation and avoid deadlock. Scenario Three contemplates that

---

31. *See* David P. Angel, RESTRUCTURING FOR INNOVATION: THE REMAKING OF THE U.S. SEMICONDUCTOR INDUSTRY 38–39 (1994); David J. Teece, MANAGING INTELLECTUAL CAPITAL: ORGANIZATIONAL, STRATEGIC AND POLICY DIMENSIONS 199–201 (2000); Peter C. Grindley & David J. Teece, *Managing Intellectual Capital: Licensing and Cross-Licensing in Semiconductors and Electronics*, 39 CALIF. MGMT. REV. 8, 20–22 (1997).

32. *See infra* notes 112–121 and accompanying text.

33. *See* Grindley & Teece, *supra* note 31, at 12.

34. *See id.* at 13, 20–22. For related observations, see Hall & Ziedonis, *supra* note 30, at 109–10.

AC effects may be mitigated or extinguished in large-number, heterogeneous-value settings insofar as intermediaries have profit incentives to devise a transactional solution to any potential IP deadlock on terms that attract the greatest number of patent holders.

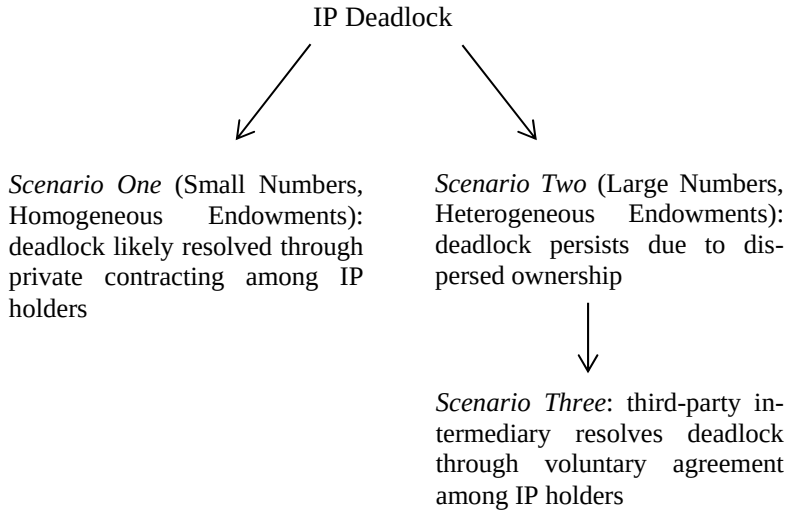

Figure 2: Are Anti-Commons Effects Likely to Persist?

1. Small Numbers, Homogeneous Endowments

Any market in which a required package of IP rights is disaggregated among a small number of rights holders has the lowest risk of AC effects. This is for three reasons: (1) the identification, communications, and negotiation costs required to reach agreement among a small number of holders are unlikely to be exorbitant; (2) given that each holder has a significant stake in the total package of IP rights and the corresponding set of technology or creative assets, each holder has a strong incentive to incur the transaction costs required to reach a mutually acceptable arrangement; and (3) to the extent that each holder is a repeat player in the relevant market, any revenue division agreed upon by the rights holders will tend to be self-enforcing without the necessity for costly formal enforcement. This is not to say that all small-numbers environments will overcome bargaining deadlocks with ease. Information asymmetries, strategic behavior, and lack of negotiation experience could block a deal and suppress the joint surplus that could have been created and split by agreement among multiple IP holders. Subject to those real-world complications, IP

deadlocks are less likely to persist in environments populated by a concentrated group of repeat players that have a strong interest and capacity to agree upon, and then adhere to, a mutually acceptable division of market rents. Given a rational interest in preserving expected future gains from cooperative behavior, repeat-play entities have strong incentives to negotiate and adhere to any such agreement. The likelihood of any such agreement increases even further when rights holders hold comparably valued endowments. Following the reasoning set forth above, if deadlocked parties hold roughly equally valuable IP portfolios, then there is greater assurance that inter-firm knowledge flows will be roughly reciprocal over time, which bolsters each firm's incentives to enter into, and adhere to, a contractual or other transactional arrangement to resolve the deadlock.

2. Large Numbers, Heterogeneous Endowments

Under the standard AC thesis, the large-numbers, heterogeneous-endowments scenario features the greatest transactional obstacles to resolving deadlocks, and thus the highest level of AC risk. However, this analysis stops too soon. If there exists a market in which rights are dispersed among multiple holders, and there are net gains to be earned by aggregating those rights, then there exists an unexploited profit opportunity. Absent legal or technological constraints, it is not expected that markets would leave profit opportunities unexploited. Hence, any deadlock in an IP-protected market invites organizational innovation by entrepreneurs who can devise transactional structures to overcome bargaining obstacles, generate revenues by consolidating those IP rights, and earn a share of the resulting net gains. Even if no individual rights holder has sufficient rational interest in incurring the costs required to devise and implement any such transactional solution, an entrepreneur that contemplates administering a market-wide IP portfolio and earns fees from administering that portfolio over a sufficiently long period of time does have such an interest. As will be shown in detail, transactional intermediaries have entered several content and technology markets to provide precisely this function.[35] The possibility of transactional intermediation is critical because it means that AC effects are unlikely to persist even in high-risk environments characterized by large numbers and endowment heterogeneity.

35. On intermediaries in ICT and content markets, see *infra* Part III.C.3.b.

III. EMPIRICS: EVIDENCE OF MARKET SOLUTIONS TO ANTI-COMMONS PROBLEMS

Based on the discussion above, a nuanced formulation of the AC thesis shows that its scope of application is most likely restricted to settings characterized by the following features:

(i) products that embody multiple technological or creative components with few actual or potential substitutes;
(ii) large numbers of IP holders;
(iii) significant differences in the value of holders' IP endowments; and
(iv) legal or technological obstacles blocking entry by third parties willing to devise transactional solutions to an IP deadlock.

Whether the AC thesis has a meaningful scope of application as a practical matter is therefore an empirical question as to the frequency with which these circumstances are realized in practice. Below, I review and present three bodies of evidence that relate to this question. First, I review existing studies that sought to assess AC effects in contemporary technology markets. Second, I survey a reasonably comprehensive set of documented IP-pooling and similar arrangements in technology and creative markets from 1900 through the present. Third, I present more granular evidence concerning selected markets in which AC effects were precluded or mitigated through transactional solutions adopted by IP holders or devised by third-party entrepreneurs.

All three bodies of evidence support a single conclusion. Over a century's worth of experience delivers little indication that markets suffer from persistent AC effects and ample confirmation that markets take measures to mitigate or preempt those effects.

A. Contemporary Evidence

The frequency with which the AC thesis is asserted with respect to contemporary IP markets is roughly inversely proportional to the evidence that has been accumulated in its support.[36] Remarkably, a

36. For similar observations, see generally Chester Shiu, *Of Mice and Men: Why an Anticommons Has Not Emerged in the Biotechnology Realm*, 17 TEX. INTELL. PROP. L.J. 413, 414–15 (2009); Edmund Kitch, *Comment on the Tragedy of the Anticommons in Biomedical Research*, 50 ADVANCES IN GENETICS 271 (2003); Richard A. Epstein & Bruce N. Kuhlik, *Is There a Biomedical Anticommons?*, REGULATION, Summer 2004 54; David E. Adelman, *A Fallacy of the Commons in Biotech Patent Policy*, 20 BERKELEY TECH. L.J. 985, 985–86 (2005). For related views, see F. Scott Kieff, *Coordination, Property, and Intellectual Property: An Unconventional Approach to Anticompetitive Effects and Downstream Access*, 56 EMORY L.J. 327, 327 (2006).

thesis that has become one of the core grounds for relaxing patent protection has never amassed compelling empirical support. Typical assertions of the AC thesis rely on the theoretical possibility that high levels of patent issuance and enforcement are likely to impede innovation, in some cases complemented by a single or handful of anecdotal examples.[37] Two bodies of evidence give reasons to doubt the empirical force of the AC thesis with respect to contemporary markets. First, there is little to no evidence of any decline in innovative output, or rise in prices, in information and communications technology ("ICT") markets that are most susceptible to AC effects. Second, studies that directly seek to identify AC effects in biomedical and related scientific research fields — the context in which the AC thesis was originally asserted in the IP context — find little evidence in support of this thesis. While we cannot exclude the counterfactual that innovation would be even stronger under weaker patent protection,[38] we can observe that there is little affirmative support for the argument that current levels of patent protection are inducing AC effects that impede innovation.

1. Indirect Evidence: ICT Markets

ICT markets would seem to be a fertile ground for AC effects: electronics and communications products often consist of multiple components, each of which is manufactured by tens or hundreds of dispersed firms.[39] In the case of any given device, there may be tens, hundreds, or even thousands of patents that cover various components in that device.[40] The expected result is a patent deadlock that hampers innovation through a combination of hold-up behavior and royalty stacking. But there is no evidence that innovation has slowed or that prices have increased in these markets.

---

37. For an example of such an assumption in a widely-cited source for the AC thesis, see Shapiro, *supra* note 12, at 121–22 (assuming that a patent thicket exists in certain technology industries, but citing no specific examples). For an example of use of anecdotal data, see FTC REPORT, *supra* note 6, at 24 (citing example of the Enbrel firm "which was subject to royalties paid to seven companies," although the report never specifies what percentage the royalty constituted of the sale price).

38. For fuller discussion of this possibility, see *infra* Part V.A.

39. *See* Jason Dedrick, Kenneth L. Kraemer & Greg Linden, Who Profits from Innovation in Global Value Chains? A Study of the iPod and Notebook PCs (2008), http://web.mit.edu/is08/pdf/Dedrick_Kraemer_Linden.pdf [http://perma.cc/TEH3-D9GX] (unpublished manuscript) (providing a "teardown" of the Apple iPod and HP notebook PC, observing that an iPod contains hundreds of components, a notebook computer can include thousands of components, and, in both cases, those components are made by a globally dispersed network of manufacturers, which are then assembled by original equipment manufacturers).

40. *See* EXEC. OFFICE OF THE PRESIDENT, PATENT ASSERTION AND U.S. INNOVATION 8 (2013) (stating that "a single smartphone may read on over 100,000 patents").

Just the opposite has occurred. Throughout a period in which patent applications and issuance have grown at historically significant rates,[41] various measures indicate that innovation in the ICT sector has continued at robust levels and prices have steadily fallen. On the supply side, private R&D spending in the U.S. computing and electronics industries has grown almost every year for the period 1998–2013.[42] On the demand side, consumers of electronics goods have enjoyed an uninterrupted flow of new products, increasing output and declining prices during that same period.[43] Consider the computer industry: prices for computers and peripheral equipment have declined every year from 1995 through the present,[44] while worldwide shipments of servers, desktops and laptops have increased from 1.1 million units in 1980 to an estimated 517 million units as of 2015.[45] Data collected by other researchers with respect to telephone equipment, televisions, personal computers, and portable computing devices — all patent-intensive industries — shows relative price declines (adjusted for quality) over the period 1992–2013 and especially dramatic declines since 2005.[46] If we look more closely at particular segments of the information technology industry, the same pattern indicative of a healthy competitive market — declining prices and increasing output — repeats: (1) worldwide shipments of smartphones increased from one-half billion units in 2011 to over one billion units in 2013;[47] (2) worldwide shipments of tablet computers increased from zero in 2010 to slightly more than 200 million in 2013;[48] and (3) worldwide

41. *See supra* note 10.

42. *See* BOOZ & CO., NAVIGATING THE DIGITAL FUTURE: THE 2013 GLOBAL INNOVATION 1000 STUDY 14 (2013), http://www.strategyand.pwc.com/media/file/Strategyand_2013-Global-Innovation-1000-Study-Navigating-the-Digital-Future_Fact-Pack.pdf [http://perma.cc/Q9J2-RUPU] (stating that as a percentage of firm revenues R&D expenditures have held constant throughout this period).

43. *See* Jason Dedrick & Kenneth L. Kraemer, *Personal Computing*, *in* INNOVATION IN GLOBAL INDUSTRIES: U.S. FIRMS COMPETING IN A NEW WORLD 19, 23, 41–42 (Jeffrey T. Macher & David C. Mowery eds., 2008). *See generally* Jonathan M. Barnett, *From Patent Thickets to Patent Networks: The Legal Infrastructure of the Digital Economy*, 55 JURIMETRICS 1 (2014) [hereinafter Barnett, *Patent Networks*] (noting that prices for computer hardware have declined).

44. *See* Dedrick & Kraemer, *supra* note 43, at 42.

45. *See Worldwide PC Market, Executive Summary*, ETFORECASTS, http://www.etforecasts.com/products/ES_pcww1203.htm [http://perma.cc/85JV-G6CA].

46. *See* Alexander Galetovic, Stephen Haber & Ross Levine, *Patent Holdup: Do Patent Holders Holdup Innovation?* (Hoover Inst. Working Grp. on Intellectual Prop., Innovation, & Prosperity, Paper No. 14011, 2014) (finding that, for the period 1992–2013, the quality-adjusted relative prices of portable laptops, computers, and personal digital assistants fell by 26.7% per year, televisions fell by 14.4% per year, and telephone equipment fell by 6.7% per year).

47. *See* Press Release, Int'l Data Corp., Worldwide Mobile Phone Market Forecast to Grow 7.3% in 2013 Driven by 1 Billion Smartphone Shipments (Sept. 4, 2013), http://www.reuters.com/article/2013/09/04/ma-idc-idUSnBw045542a+100+BSW20130904 [http://perma.cc/4378-N4R5].

48. *See* Press Release, Int'l Data Corp., IDC Forecasts Worldwide Tablet Shipments to Surpass Portable PC Shipments in 2013 (May 28, 2013),

shipments of Bluetooth-enabled devices increased from zero in 2000 to approximately 2.5 billion units as of year-end 2013.[49] If there is an AC effect in the electronics and communications markets, it has yet to be realized.

2. Direct Evidence: Biomedical and Other Scientific Research

As applied to the IP context, the AC thesis was initially formulated, and has been most commonly discussed, in the context of biomedical research. Scholars in both the legal and economics communities predicted that AC effects would emerge as a consequence of the strengthening of patent rights following passage of the Bayh-Dole Act in 1980[50] (which authorized recipients of federal research funding to patent innovations developed using that funding) and the establishment of the U.S. Court of Appeals for the Federal Circuit in 1982.[51] The rationale was simple: increased patenting in biomedical research would generate transaction costs that slow down the information exchange required to promote innovation.[52] But there is one problem with this theory. The evidence collected to date does not support it.

Multiple empirical studies have scrutinized extensively the biomedical and scientific research fields for symptoms of AC effects since the early 1980s. These studies fall into two main categories: (1) studies that survey scientific researchers to assess the effects of increased patenting on innovation; and (2) studies that use citation data to assess those effects. Both types of study indicate that the expansion of patenting has not resulted in any significant adverse effects on scientific research.[53]

---

http://www.reuters.com/article/2013/05/28/ca-idc-idUSnBw285767a+100+BSW20130528 [http://perma.cc/A7CA-V99L].

49. *See History of the Bluetooth Special Interest Group*, BLUETOOTH SIG, INC., http://www.bluetooth.com/Pages/History-of-Bluetooth.aspx [http://perma.cc/M7P8-U9QB].

50. Patent and Trademark Law Amendments Act of 1980, Pub. L. No. 96-517, 94 Stat. 3015 (codified at scattered sections of the United States Code).

51. *See supra* note 4. For an economist who expressed similar concerns, see generally Richard R. Nelson, *The Market Economy and the Scientific Commons*, 33 RES. POL'Y 455 (2004).

52. *See generally* Heller & Eisenberg, *supra* note 4.

53. My review below focuses on the most widely discussed empirical studies on AC effects in current biomedical research communities. For similar conclusions based on a comprehensive review, see McManis & Yagi, *supra* note 8, at 1060–73. The negative empirical results are acknowledged with various qualifications by the scholars who initially applied the AC thesis to the biomedical research context. *See* Rebecca S. Eisenberg, *Noncompliance, Nonenforcement, Nonproblem? Rethinking the Anticommons in Biomedical Research*, 45 HOUS. L. REV. 1059, 1061 (2008) (acknowledging weak evidence for the anti-commons thesis and re-crafting the thesis to capture transaction costs attributable to contractual negotiations concerning use of research materials); HELLER, *supra* note 4, at 65–67 (acknowledging weak evidence for the anti-commons thesis in biomedical research but interpreting it as inconclusive).

Extensive survey studies of biomedical researchers in the United States and other countries provide little evidence that increased patenting has had significant incremental adverse effects on biomedical innovation, in the form of either delayed or halted projects.[54] The survey results are consistent across different samples and countries.[55] A review of these surveys by leading researchers in the field concludes: "[L]egal excludability due to patents does not appear in practice to impose an important impediment to academic research in biomedicine . . . ."[56] Some specific reasons offered for these findings include:

(i) patent enforcement is not cost-effective or time-effective;[57]

(ii) fees for using the patented technology were nominal;[58]

54. *See* Wesley M. Cohen & John P. Walsh, *Real Impediments to Academic Biomedical Research*, *in* 8 INNOVATION POLICY AND THE ECONOMY 1, 10–11 (Adam B. Jaffe, Josh Lerner & Scott Stern eds., 2008) (reviewing multiple surveys of industry and academic scientists and finding that patent-related access limitations or other "anticommons" effects rarely impede research). For specific studies, see generally Zhen Lei et al., *Patents Versus Patenting: Implications of Intellectual Property Protection for Biological Research*, 27 NATURE BIOTECH. 36 (2009) (reporting survey findings showing that scientists "do not [generally] encounter an anti-commons or a patent thicket" but that mandated technology transfer agreements can slow down the exchange of research tools, and reporting perception that those agreements are associated with an academic environment in which patenting is encouraged); Yuan-Chieh Chang & Phil Y. Yang, *The Impacts of Academic Patenting and Licensing on Knowledge Production and Diffusion: A Test of the AC Effect in Taiwan*, 38 R&D MGMT. 321 (2008) (finding positive relationship between patenting, licensing and publication, but finding delays in disclosure due to researchers' involvement in licensing activities, based on a survey of all Taiwanese researchers granted patents during a three year period); STEPHEN HANSEN ET AL., AM. ASS'N FOR THE ADVANCEMENT OF SCI., INTELLECTUAL PROPERTY IN THE AAAS SCIENTIFIC COMMUNITY 3 (2005) (finding, based on survey of over 1,000 randomly selected scientific researchers from academic and commercial fields that, while patenting was prevalent, most patentees then disseminated the underlying technology through informal sharing or publication); John P. Walsh, Ashish Arora & Wesley M. Cohen, *Effects of Research Tool Patents and Licensing on Biomedical Innovation*, *in* PATENTS IN THE KNOWLEDGE-BASED ECONOMY 285–340 (Wesley M. Cohen & Stephen A. Merrill eds., 2003) [hereinafter *Effects of Research Tool Patents*] (finding little evidence, from survey of limited sample of industry and academic researchers, that access restrictions attributable to patents delayed or stopped research projects or had significant effects on knowledge-sharing among researchers); John P. Walsh, Charlene Cho & Wesley M. Cohen, *View from the Bench: Patents and Material Transfers*, 309 SCIENCE 2002 (2005) (finding that only one percent out of 414 interviewed academic biomedical researchers reported any delay in research, and none reported halting research, due to access constraints attributable to patents); John P. Walsh, Ashish Arora & Wesley M. Cohen, *Working Through the Patent Problem*, 299 SCIENCE 1021 (2003) (finding that scientific research communities have developed work-around solutions to patent-related transactional obstacles or, in some cases, follow norms that tolerate limited infringement, based on interviews with seventy IP attorneys, scientists, and managers from pharmaceutical firms, biotech firms, and universities).

55. *See* Cohen & Walsh, *supra* note 54, at 11.

56. *Id.* at 17.

57. *See id.* at 12–13.

58. *See* Walsh, Cho & Cohen, *supra* note 54, at 2002.

(iii) researchers can design around the applicable patent;[59]

(iv) researchers ignore the applicable patent and the patentee is either unaware of, or tolerates, the unauthorized use;[60]

(v) researchers use contractual or technological methods to constrain access to research results, databases, materials, or processes;[61] and

(vi) researchers conform to reciprocity norms that promote knowledge sharing among academic institutions.[62]

Other studies have sought to assess whether patenting activity depresses subsequent innovation by using journal citation rates as a proxy for the dissemination of knowledge among the research community. The results are more mixed but do not establish significant adverse effects attributable to increased patenting activity,[63] in part because it is not clear that citation rates reliably proxy for access to knowledge.[64]

---

59. *See* Cohen & Walsh, *supra* note 54, at 12; *Effects of Research Tool Patents*, *supra* note 54, at 323.

60. *See* Cohen & Walsh, *supra* note 54, at 12; Lei et al., *supra* note 54, at 37, 39; Walsh, Cho & Cohen, *supra* note 54, at 2002.

61. This refers principally to denials of access to non-patented research materials. *See* Cohen & Walsh, *supra* note 54, at 13–15; Lei et al., *supra* note 54, at 36–38.

62. *See* Cohen & Walsh, *supra* note 54, at 3; *Effects of Research Tool Patents*, *supra* note 54, at 325─27; *cf.* HANSEN ET AL., *supra* note 54, at 5, 16 (noting that academia still uses some informal forms of technology transfer and has been less affected than industry by formal licensing practices).

63. One study found a statistically significant but modest adverse effect on knowledge-sharing attributable to patents, as measured by a decline in the forward citation rate of publications following a patent grant. *See generally* Fiona Murray & Scott Stern, *Do Formal Intellectual Property Rights Hinder the Free Flow of Scientific Knowledge? An Empirical Test of the Anti-Commons Hypothesis*, 63 J. ECON. BEHAV. & ORG. 648 (2007). Another study found that university licensing of patented knowledge is associated with an increase in journal citation rates, but a decrease in citation rates when the underlying discovery is a research input, as indicated by the use of a material transfer agreement. *See* David C. Mowery, Neil C. Thompson & Arvids A. Ziedonis, Does University Licensing Facilitate or Restrict the Flow of Knowledge and Research Inputs Among Scientists? (May 15, 2014) (unpublished manuscript). Another study claims to detect AC effects in a sample set of pharmaceutical products based on the finding that most top-selling products involve small numbers of licensed patents. *See* Stu Woolman, Elliot Fishman & Michael Fisher, *Evidence of Patent Thickets in Complex Biopharmaceutical Technologies*, 53 IDEA 1, 21 fig.3 (2013). However, this evidence is ambiguous; there could be several other reasons why pharmaceutical companies tend not to license other patents — most notably, the fact that pharmaceutical products often rely on only a single patent or a small number of patents.

64. There may be other reasons why patenting knowledge disclosed in an academic publication generates lower subsequent citation rates. As McManis and Yagi observe, *supra* note 8, at 1066–67, observed declines in citation rates may not indicate adverse effects on research and innovation if patenting signals to researchers that resources are better allocated to other fields of inquiry. For similar observations, see Cohen & Walsh, *supra* note 54, at 11–12.

This is not to say that these empirical studies have definitively settled the debate as to whether increased patenting in the biomedical field has resulted in a net welfare loss in the form of reduced innovation. One study found some modest delays in disclosure and another attributed exclusionary behavior to an environment in which researchers are permitted or encouraged to seek patents.[65] More generally, we cannot exclude the possibility that the biomedical research community would exhibit even greater innovation, or more precisely, would generate even greater net social wealth, under weaker levels of IP protection. But we also cannot exclude the possibility that this community would exhibit even greater innovation, or would generate even greater net social wealth, under still stronger levels of IP protection. At a minimum, there does not currently seem to be compelling support for the anticipated causal sequence extending from increased patenting to increased transaction costs to reduced innovation in biomedical and other scientific research fields.[66]

B. Historical Evidence: All Markets

Historical evidence provides a richer stock of experience from which to assess the extent to which the AC thesis is realized in real-world markets. To survey this evidence, I have compiled a reasonably comprehensive set of documented patent pooling and cross-licensing arrangements relating to U.S. markets for the period 1900 through the present, as compiled through a review of court decisions, congressional hearings, contemporary press coverage, scholarly commentary, and other sources.[67] For this purpose, a "pool" includes any horizontal arrangement in which three or more entities agreed to cross-license patents, copyrights, or other IP rights pursuant to a contractual agree-

65. *See generally* Lei et al., *supra* note 54 (documenting exclusionary behavior); Chang & Yang, *supra* note 54 (documenting disclosure delay). However, another study finds that, while denials of requests to access research materials are significant, the incidence of such denials shows no relationship with the existence of a patent. *See* Walsh, Cho & Cohen, *supra* note 54, at 2003.

66. Additionally, there is support for the alternative (and curiously overlooked) possibility that increased patenting has encouraged increased investment in research and commercialization activities in this field. *See* Jerry G. Thursby & Marie C. Thursby, *Has the Bayh-Dole Act Compromised Basic Research?*, 40 RES. POL'Y 1077, 1083 (2011).

67. For a description of all sources and the search methodology, see *infra* Appendix. For the most detailed existing source of information on historical patent pools, see Josh Lerner, Marcin Strojwas & Jean Tirole, *Cooperative Marketing Agreements Between Competitors: Evidence from Patent Pools* (Nat'l Bureau of Econ. Research, Working Paper No. 9680, 2003). Lerner et al. state that they identified approximately 125 pools between 1856 and 2001 but provide identifying information on only 63 pools. *See id.* at 13–14. The larger number of pools identified by Lerner et al. may be due to the fact that they covered a somewhat longer historical period, drew on a different set of sources, and/or used broader criteria for defining a pool. *See id.* at 2.

ment, or to aggregate certain IP rights in a single entity.[68] The set of pools I identified inherently underestimates the actual set of total pools since it does not include pools or similar arrangements that were not litigated, did not result in a court decision, or were otherwise not publicly documented or captured by the sources used to compile this list.[69] Figure 3 depicts the documented pools, which I have identified specifically in the Appendix.

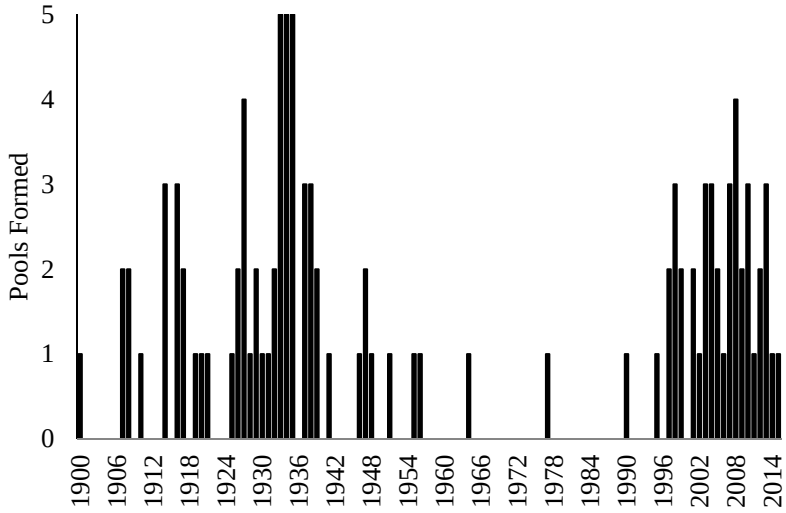

Figure 3: Documented IP Pools (1900–July 2015)

This survey supports a simple but important observation. Prior scholarship has focused on the pooling arrangements administered by intermediaries such as the American Society of Composers, Authors and Publishers ("ASCAP") and Broadcast Music, Inc. ("BMI"), which formed and administer pools to which hundreds of thousands of individuals and entities have contributed IP rights related to musical performances.[70] This evidence shows that the phenomenon extends broadly across a wide range of periods and markets. Other than times when antitrust law restricted pooling arrangements, technology and

68. While the threshold requirement of three members excludes some arrangements referred to as "patent pools," it is necessary to avoid capturing the much larger population of generic bilateral licensing agreements. I excluded: (1) vertical licensing arrangements solely involving a single entity that holds a pool of patents, which it then licenses to downstream users; (2) mergers between companies that held IP assets; and (3) licensing agreements between a standard-setting organization and a patentee whereby the latter agrees to license its contributed IP on "reasonable and non-discriminatory" terms.

69. For the full list of sources, see *infra* Appendix.

70. For the leading academic source, see generally Merges, *Contracting into Liability Rules*, *supra* note 5.

content markets have repeatedly entered into pooling and cross-licensing arrangements to address potential AC effects in IP-intensive markets. Since 1900, available evidence shows that IP holders have formed IP pools or similar cross-licensing arrangements at least 105 times: 83 times by small groups of IP holders (less than 10 members), and 22 times by large groups of IP holders (10 or more members).[71] Consistent with theoretical expectations, large groups of IP holders typically rely on a third-party entity to form and administer the pooling arrangement (and have done so in the case of every large-number pooling arrangement formed since 1939).[72]

The only exception to this regular pattern of pool formation is the period from the 1940s through the early 1980s. That hiatus almost certainly resulted from an antitrust quasi-prohibition of pooling arrangements from the early 1940s through the 1970s. Starting in the late New Deal period and against the backdrop of World War II, the Roosevelt administration launched an attack on what were known as "patent trusts" — essentially, cross-licensing arrangements involving incumbents in various industries.[73] As discussed subsequently, the antitrust agencies undertook enforcement actions that resulted in the dissolution or modification of ninety percent of documented patent pooling arrangements that had been established during the years 1930–1938.[74] After the war, the high liability risk associated with patent pooling persisted as the Supreme Court struck down patent cross-licensing arrangements on antitrust grounds.[75] This hostility to pooling and cross-licensing continued through the 1970s as agency actions and court decisions implemented explicit or implicit per se liability rules with respect to tying, resale price maintenance, and other IP licensing terms.[76]

The post-war de facto suppression of patent pooling was tacitly lifted through three steps. In the early 1980s, the courts adopted a less

---

71. *See infra* Appendix.

72. *See id*.

73. In 1942, the assistant attorney general of the Antitrust Division of the Department of Justice, Thurman Arnold, stated before a congressional committee: "The committee . . .has investigated the patent system at a time when it was never more important that we have full and unhampered production and that American business be entirely free of either old or prospective commitments to cartels." He continued, "[t]oday, largely through the work of this committee, we have learned that the production and distribution of vital elements . . .have been seriously impeded and delayed and in some cases totally blocked by patent restriction." *See Patents: Hearings on S. 2303 and S. 2491 Before the S. Comm. on Patents*, 77th Cong., 2d Sess. 3279–80 (1942) (Statement of Thurman Arnold, Ass't Atty. Gen., Antitrust Div., Dept. of Just.).

74. *See infra* Table 3. For more specific information, see *infra* Appendix.

75. *See, e.g.*, Hartford-Empire Co. v. United States, 323 U.S. 386, 401–02 (1945); United States v. Line Material Co., 333 U.S. 287, 287 (1948) (reversing and remanding dismissal of government's antitrust case against power generation electronics patent pool).

76. *See* Robert J. Hoerner, *The Decline (and Fall?) of the Patent Misuse Doctrine in the Federal Circuit*, 69 ANTITRUST L.J. 669, 671–72 (2001) (citing numerous cases).

aggressive approach to antitrust enforcement: the Supreme Court endorsed a "rule of reason" approach under which cooperative licensing arrangements could pass muster if shown to yield net pro-competitive effects.[77] The effect of this regime shift was immediate: from 1980 to 1989, the number of private antitrust actions declined from about 1400 per year to 638.[78] In 1995, the Department of Justice and the Federal Trade Commission issued revised antitrust guidelines that prescribed a broader rule of reason approach covering most licensing practices.[79] In 1997, the Department of Justice issued a "business review letter" indicating effective approval of a proposed patent pool for certain audio and video compression technologies.[80] In the wake of these judicial and regulatory signals, IP markets returned to the historical norm: pooling arrangements re-emerged to address and preempt the transaction cost burdens inherent to intensive patent issuance and enforcement.[81] As I discuss subsequently, the ICT sector has formed patent-pooling arrangements with particular intensity since the late 1990s.

As stated previously, a nuanced formulation of the AC thesis anticipates that markets will have strong incentives and capacities to devise transactional solutions that mitigate or preclude AC effects. Consistent with this formulation, intensive patent infringement litigation preceded the formation of some of the most well-known patent pools in the 20th century. The rationale seems clear: the high costs of patent litigation drive parties to devise transactional arrangements that avoid those costs and generate economic gains for all affected constituencies. As I discuss in Part C below, these litigations resulted in the formation of the Association of Licensed Automobile Manufacturers (1903), the Automobile Manufacturers' Association (1915), the Manufacturers' Aircraft Association (1917), the Radio Corporation of America (1919), and various pools entered into by petroleum refiners in the 1930s.[82]

This repeated pattern of parties who litigate/threaten to litigate, then pool, does not extinguish concerns that intensive levels of patent issuance and enforcement can block innovation, divert social resources or impose other adverse welfare effects. There may be signifi-

---

77. Broad. Music. v. Columbia Broad., 441 U.S. 1, 2 (1979).

78. *See* U.S. GEN. ACCT. OFF., DEP'T. OF JUST., CHANGES IN ANTITRUST ENFORCEMENT POLICES & ACTIVITIES 15 (1990).

79. *See* DEP'T. OF JUST. & FED. TRADE COMM'N, ANTITRUST GUIDELINES FOR THE LICENSING OF INTELLECTUAL PROPERTY 16 (1995).

80. Letter from Joel I. Klein, Asst. Att'y Gen., Antitrust Div., Dep't. of Just., to Gerrard R. Beeney, Esq., Sullivan & Cromwell 1, 16 (June 26, 1997) (indicating no intention to initiate antitrust enforcement against proposed patent licensing arrangement), http://www.justice.gov/atr/public/busreview/215742.htm [http://perma.cc/9ELS-N48K].

81. *See supra* Figure 3.

82. For further details, see *infra* Appendix. For further discussion of the petroleum refining, aircraft and radio patent pools, see *infra* Parts III.C.2, IV.A, and IV.B, respectively.

cant adverse effects on innovative output during the intense but short-lived periods of patent infringement that typically precede pool formation. Whether that raises net welfare concerns is an indeterminate task that requires taking into account the incentive effects of robust IP protection on long-term innovative output.

What is clear, however, is that this observed pattern of litigation plus settlement casts doubt on the extent to which AC effects will persist. Such effects are unlikely to endure in low-risk environments populated by small numbers of entities with comparable IP assets. And given the possibility of transactional intermediaries, AC effects may be short-lived even in environments with large numbers of entities holding heterogeneous IP assets. Rather than suffering chronically from the transaction cost burdens inherent to robust IP rights, markets tend to innovate structures that mitigate those burdens and facilitate transactions in those rights.

C. Historical Evidence: Selected Markets

Global evidence on market responses to AC effects establishes a tentative case that those effects are generally unlikely to persist, because markets have incentives and capacities to develop organizational structures to mitigate such effects. Closer examination of specific cross-licensing or similar arrangements throughout the 20th and 21st centuries provides additional insight into the effectiveness with which particular IP-intensive markets have used contracting structures to address AC effects. Each market displays a similar pattern: an initial period of intensive disputes over conflicting IP claims concludes either by mutual agreement among IP holders or the emergence of third-party intermediaries that provide an effective rights-administration solution.[83]

1. Automobiles

The automobile industry appears to be a fertile breeding ground for value-depleting patent disputes and hold-up behavior. The automobile consists of thousands of components, and the considerable lag

83. The following discussion omits the sewing machine market, which provides a well-documented case of market self-resolution of an intensive patent dispute. For the leading studies, see Adam Mossoff, *The Rise and Fall of the First American Patent Thicket: The Sewing Machine War of the 1850s*, 53 ARIZ. L. REV. 165, 170 (2011); Ryan L. Lampe & Petra Moser, *Do Patent Pools Encourage Innovation? Evidence from the 19th-Century Sewing Machine Industry* (NBER Working Paper No. 15061, 2009). I exclude this episode because it falls before the start of the historical period covered by this paper. Additionally, I do not discuss the ASCAP and BMI entities, which formed and administered pools for public performance rights of copyrighted musical compositions, which have been ably documented by Professor Robert Merges. *See generally* Merges, *Contracting into Liability Rules*, *supra* note 5.

between its production and design schedules does not allow for rapid design-arounds to address infringement claims.[84] Consistent with these expectations, commentators often claim or assume that the pioneering "Selden" patent over the internal combustion engine blocked entry and delayed innovation in the early years of the automotive industry.[85] Yet William Greenleaf's 1962 history of the automobile industry states: "It has also been held that the Selden patent shackled investment, production, and technical innovation in the industry as a whole. Such claims have no foundation in fact."[86] A closer look at the evidence shows why Greenleaf doubted the conventional wisdom that has prevailed to this day. Through cooperative action, the automobile industry has consistently precluded or mitigated patent-related disputes and resulting delays to commercial activity.

A. The First Automotive Patent Pool (1903–1911)

During the first decade of the 20th century, thirty-two U.S. automotive firms operated pursuant to a license from the Association of Licensed Automobile Manufacturers ("ALAM"), which controlled the Selden patent.[87] Specifically, the Selden patent claimed a "liquid hydrocarbon engine of the compression type" for use in a "road-locomotive."[88] ALAM was formed in 1903 in connection with a settlement of patent infringement litigation brought by the holder of the Selden patent.[89] ALAM licensed its patent widely for 1.25% of a car's sale price,[90] reduced in 1907 to 0.8%.[91]

---

84. *See* CHARLES H. FINE ET AL., THE U.S. AUTOMOBILE INDUSTRY 21, 25 (U.S. Dep't. of Com., Off. of Tech. Pol'y 1996) (stating that average "time to market" for a U.S. automobile manufacturer was fifty-two months and noting that the "automobile is one of the most complex consumer products in existence" and that it is difficult to correct defects in the manufacturing process).

85. For examples of these views, see FED. TRADE COMM., TO PROMOTE INNOVATION: THE PROPER BALANCE OF COMPETITION & PATENT LAW AND POLICY 3 (2003); Tim Wu, *Intellectual Property, Innovation, & Decentralized Decisions*, 92 VA. L. REV. 123, 136–37 (2006); Alexander Tabarrok, *Patent Theory versus Patent Law*, 1 CONTRIBUTIONS IN ECON. ANALYSIS & POL'Y 1, 13 n.20 (2002). For a more qualified view, see Robert P. Merges & Richard R. Nelson, *On the Complex Economics of Patent Scope*, 90 COLUM. L. REV. 839, 889–91 (1990) (noting that the Selden patent may have restrained innovation and discouraged entry but observing that the industry formed a cross-licensing organization that endured).

86. WILLIAM GREENLEAF, MONOPOLY ON WHEELS: HENRY FORD & THE SELDEN AUTOMOBILE PATENT 237 (1961).

87. *See* JAMES J. FLINK, THE AUTOMOBILE AGE 52 (1990). More precisely, the Selden patent was held by the Electric Vehicle Company, which received a royalty from ALAM. *See id.*

88. U.S. Patent No. 549,160 (issued Nov. 5, 1895).

89. *See* RALPH C. EPSTEIN, THE AUTOMOBILE INDUSTRY 228–29 (1928).

90. *See id.* at 365 (citing ALAM's articles of agreement on licensing).

91. *See id.* at 232. On ALAM's liberal licensing policy, see JOHN B. RAE, AMERICAN AUTOMOBILE MANUFACTURERS: THE FIRST FORTY YEARS 75–78 (1959).

Multiple indicators show that this royalty burden had no adverse effect on industry growth and may have promoted growth by facilitating technical standardization.[92] First, as shown in the Figures 4 and 5 below, automotive production expanded throughout this period.[93] Second, significant portions of the industry sometimes operated without a license: ALAM licensees constituted only about 45% of the market in 1908, later rising to 85% in 1910 and 70% in 1911.[94] Third, there was robust entry into the industry: during 1903–1911 (the period spanning formation of ALAM until the end of the Selden patent litigation), sixty-nine new firms entered the industry (an average of more than thirteen entrants per year) and, after accounting for business failures, the total number of firms increased from twenty-four in 1903 to fifty-three in 1911.[95] Together with other firms, three of those entrants (Buick, formed in 1904, Cadillac, formed in 1903, and Oakland, formed in 1908) later formed the General Motors Corporation.[96] Fourth, there were apparently few, if any, adverse effects on innovation: during 1903–1911, the automotive industry released multiple improvements to the drive train, manufacturing processes, bodies and chassis, and other components, while also packaging innovations in single products such as the Model T.[97]

92. ALAM promoted standardization of parts, which facilitated achieving scale economies in production. *See* EPSTEIN, *supra* note 89, at 41–43; RAE, *supra* note 91, at 79–81.

93. *See* LAWRENCE H. SELTZER, A FINANCIAL HISTORY OF THE AMERICAN AUTOMOBILE INDUSTRY 42, 45–47 (1928); GREENLEAF, *supra* note 86, at 237.

94. *See* EPSTEIN, *supra* note 89, at 230–31.

95. *See id.* at 176, chart 28. Note that this chart may underestimate entry, because it is restricted to firms that engaged in actual production or sales of automobiles. *See id.* at 163–64.

96. On formation of General Motors, see *id.* at 166, 182. On the formation dates for each constituent entity, see *id.* at 378, 380.

97. *See* WILLIAM J. ABERNATHY, KIM B. CLARK & ALAN M. KANTROW, INDUSTRIAL RENAISSANCE: PRODUCING A COMPETITIVE FUTURE FOR AMERICA, 157–59 tbl.D.1 (1983).

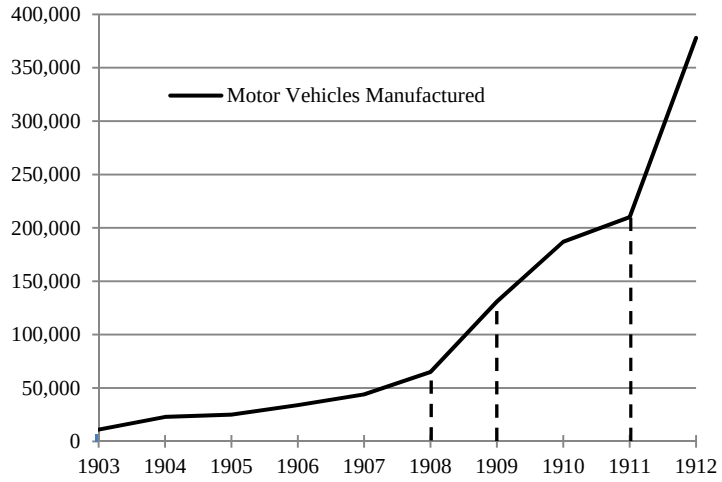

Figure 4: U.S. Production of Motor Vehicles (1903–1912)[98]

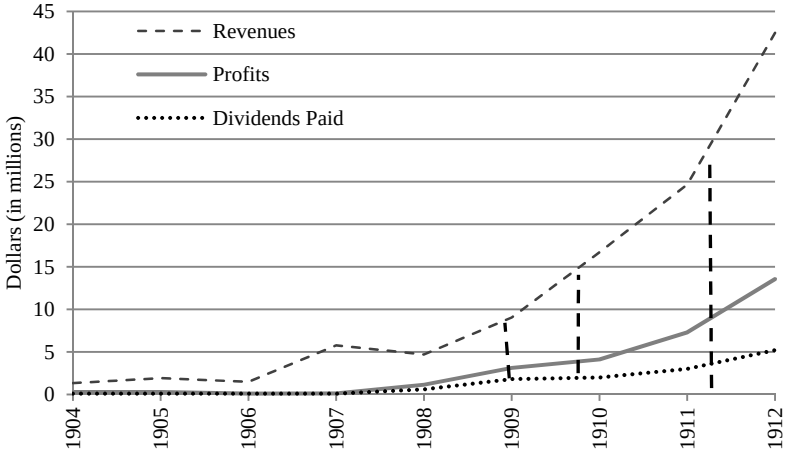

Figure 5: Revenues, Profits and Dividend Payments of Ford Motor Co. (1904–1912)[99]

Key dates: 1903: Selden patent assignee sues Ford; 1908: Release of Ford Model T; 1909: Selden patent upheld; 1911: Ford prevails in patent litigation.

98. *See* SELTZER, *supra* note 93, at 75 tbl.8 (based on data compiled by the National Automobile Chamber of Commerce).

99. *See id.* at 93 tbl.19, 96 tbl.20, 130 tbl.25.

B. The Selden-Ford Litigation (1903–1911)

The most famous alleged infringer of the Selden patent was the Ford Motor Company ("Ford"). In 1903, Ford applied for membership in ALAM, which rejected Ford's application partly on the ground that it had not demonstrated "competence" as a manufacturer.[100] Ford disregarded the Selden patent[101] and, in response, ALAM brought an infringement suit against Ford (as well as a group of unlicensed manufacturers organized as the American Motor Car Manufacturers' Association),[102] which continued to disregard the patent while the litigation was pending.[103] In 1909, the district court upheld the Selden patent[104] but did not issue an injunction against Ford, which posted a bond pending appeal.[105] In 1911, Ford prevailed on a finding of non-infringement.[106] This protracted litigation had little to no adverse effect on Ford, which enjoyed constant growth in revenues throughout this period.[107] There is no evidence that Ford restrained investment in plant capacity, dealer relationships, innovation, or other activities.[108] During the Ford-Selden litigation, Ford released thirteen new automotive innovations[109] as well as the revolutionary release of the Model T, the first passenger vehicle within the financial reach of a large consumer population.[110] As shown in Figures 4 and 5 above, both the industry and Ford experienced particularly steep growth rates after the Selden patent was upheld in 1909 and through Ford's ultimate litigation victory in 1911. While Ford's vehicle production climbed even more steeply after 1911, this appears to be a result of Ford's perfection of the moving assembly line method of production, rather than termination of the litigation.[111]

---

100. *See* FLINK, *supra* note 87, at 53.This may seem like the blatant exclusionary behavior of a cartel. However, it should be appreciated that one of ALAM's objectives was to address consumers' quality concerns in a market populated by so-called "fly by night" operations. At the time, Ford's two prior automotive businesses had failed. *See* GREENLEAF, *supra* note 86, at 107.

101. *See* FLINK, *supra* note 87, at 52–53.

102. *See* GREENLEAF, *supra* note 86, at 170–71; FLINK, *supra* note 87, at 54; EPSTEIN, *supra* note 89, at 229.

103. *See* FLINK, *supra* note 87, at 53–54.

104. *See* Elec. Vehicle Co. v. C.A. Duerr & Co., 172 F. 923, 932, 934, 937–38 (C.C.S.D.N.Y. 1909).

105. *See* GREENLEAF, *supra* note 86, at 221.

106. *See* SELTZER, *supra* note 93, at 41.

107. *See id.* at 96 tbl.20, 97; GREENLEAF, *supra* note 86, at 188, 236–37.

108. *See* GREENLEAF, *supra* note 86, at 177, 236–37.

109. *See* ABERNATHY ET AL., *supra* note 97, at 157–58 tbl.D1.

110. *See* GREENLEAF, *supra* note 86, at 191.

111. *See id.* at 237.

C. The Second Automotive Patent Pool (1915–1957) and Events Thereafter

Ford's victory in the patent litigation rendered ALAM moot. However, ALAM's licensing model was soon reconstituted in a different form. In 1915, much of the automotive manufacturing industry entered into a formal cross-licensing agreement, which was administered by a collective trade organization, the National Automobile Chamber of Commerce[112] (later known as the Automobile Manufacturers' Association). The agreement provided the Association's seventy-nine founding members with royalty-free access to each other's patents, aside from exceptional patents that were entitled to appraisal and made available subject to a royalty payment.[113] While Ford was not a member, it offered its patents at zero royalty rates to all entities that provided access to their patents on a reciprocal basis.[114] The agreement, coupled with Ford's open licensing practices, minimized patent litigation and effectively created a common technology pool from which all competitors could draw.[115] During hearings held in the late 1930s, Congress observed with praise the Association's open licensing practices.[116] At the same time, automotive manufacturers reportedly followed norms that tolerated informal reciprocal use ("horse trading") of patents[117] or entered into formal cross-licensing agreements.[118] Even after the Association and cross-licensing agreements lapsed in 1956[119] and until the early 1970s, U.S. automotive manufacturers adhered to an informal set of industry norms consisting of limited recourse to patent litigation, below-market royalty licensing rates, and limited acceptance of poaching of each firm's innovations.[120] Ev-

112. *See* SELTZER, *supra* note 93, at 44; EPSTEIN, *supra* note 89, at 236–38; GREENLEAF, *supra* note 86, at 245.

113. *See* SELTZER, *supra* note 93, at 44–45; GREENLEAF, *supra* note 86, at 245.

114. *See* FLINK, *supra* note 87, at 55.

115. *See* SELTZER, *supra* note 93, at 44–45. *See generally* Karl Fenning, *Interest of Trade Associations in Patents and Trademarks*, 3 HARV. BUS. REV. 81 (1924); Benjamin S. Kirsh, *Patent Pools and Cross Licensing Agreements*, 20 J. PAT. OFF. SOC'Y 733, 742, 744–45 (1938) (using the automobile industry as an example of a cross licensing agreement that resulted in a successful patent pool).

116. *See Investigation of Concentration of Econ. Power: Hearings Before the Temp. Nat'l Econ. Comm.* 76th Cong., 3d Sess. 18035 (1941) (stating that the "automobile industry affords a good example for those who contend that patent pools are not only necessary but that they tend to reduce the prices of commodities").

117. *See* William B. Black, *Big Auto Patent Pool, Entirely Empty Now, Will Be Refilled Soon: Cross-Licensing Pact Drafted, But There'll Still Be Some Invention "Horse-Trading,"* WALL ST. J., Jan. 30, 1947, at 1.

118. *See generally* C.A. Welsh, *Patents and Competition in the Automobile Industry*, 13 L. & CONTEMP. PROBS. NO. 2, 260, 268, 270 (1948) (stating that cross-licensing was a principal policy in the automobile industry).

119. *See* RAE, *supra* note 91, at 155.

120. *See* FLOYD L. VAUGHAN, THE UNITED STATES PATENT SYSTEM: LEGAL AND ECONOMIC CONFLICTS IN AMERICAN PATENT HISTORY 63 (1956); LAWRENCE J. WHITE, THE AUTOMOBILE INDUSTRY SINCE 1945 213–15 (1971).

idence indicates that automakers have perpetuated this historical norm against aggressive patent litigation to the present day.[121]

2. Petroleum Refining

The growth of the automobile industry in the early 20th century went hand in hand with the growth of the petroleum refining industry. The early decades of this lucrative industry exhibit symptoms of a possible patent thicket. The holders of pioneering patents for "cracking" processes — innovations that dramatically increased the efficiency of petroleum refining[122] — were embroiled in patent infringement litigations from 1916 through 1931.[123] The costs expended on these litigations were undoubtedly significant in absolute terms and inherently diverted resources from other uses, including research and development. However, contrary to standard expectations, there is no indication that these lawsuits delayed the diffusion of cracking technologies or otherwise adversely affected the retail gasoline and passenger car markets.

The core reason is the same voluntary bargaining process observed repeatedly in markets that might be prone to patent thickets. All major patent litigations were resolved through cross-licensing and pooling arrangements in 1921[124] and 1923,[125] and an acquisition transaction in 1931.[126] While antitrust authorities challenged the 1923 pooling arrangement, the Supreme Court upheld it in 1931.[127] Given latitude under the antitrust laws, the petroleum refining market anticipated and preempted patent litigation by developing the cross-licensing structures set forth in Table 1 below. Until the advent of U.S. involvement in World War II, at which time the antitrust authorities secured compulsory licensing orders with respect to five of the

121. *See* John R. Allison et al., *Valuable Patents*, 92 GEO. L.J. 435, 446, 472 (2004) (finding low incidence of litigation over automotive patents for sample population of patents issued between June 1996 and May 1998).

122. "Cracking" refers to various chemical processes for applying heat for prolonged periods to split heavy hydrocarbon molecules into lighter ones, which provides the basis for more efficiently obtaining motor vehicle gasoline from crude petroleum. *See* JOHN L. ENOS, PETROLEUM PROGRESS AND PROFITS: A HISTORY OF PROCESS INNOVATION viii (1962).

123. *See* ENOS, *supra* note 122, at 89, 114–19 (1962) (discussing patent litigation and settlements involving various holders of competing cracking processes).

124. *See* Standard Oil Co. (Indiana) v. United States, 283 U.S. 163, 167–68 (1931).

125. *See* ENOS, *supra* note 122, at 115, 118 (documenting patent pools between Gasoline Products and The Texas Company and between Texaco, Indiana Standard, Jersey Standard and Gasoline Products).

126. *See id.* at 89 (discussing transaction in which Shell, California Standard, Texaco, Jersey Standard, and Indiana Standard together purchased interests in Universal Oil Products).

127. *See* Standard Oil Co. (Indiana) v. United States, 33 F.2d 617, 632 (D. Ill. 1929), *rev'd* Standard Oil Co. (Indiana) v. United States, 283 U.S. 163 (1931).

pools listed below,[128] the market had largely resolved patent thicket effects through independent action.

Table 1: Patent Cross-Licensing Agreements in Petroleum Refining (1921–1939)

Year Est.	Market Segment	No. Members
1921–1923	Petroleum refining (cracking processes)[129]	5
1930	Petroleum refining (hydrogenation processes)[130]	4
1933	Petroleum refining (Gray Process)[131]	5
1933	Petroleum refining (Jersey Union Indiana Kellogg Group)[132]	4
1934	Petroleum refining (Fractional distillation)[133]	3
1935	Petroleum refining (Gas polymerization)[134]	5
1938	Petroleum refining (Hydrocarbon synthesis)[135]	5
1939	Petroleum refining (Sulfuric acid alkylation)[136]	4

128. *See* United States v. Standard Oil Co. (New Jersey) et al., 1940─1943 Trade Cas. (CHH) ¶ 56,198 (D.N.J. March 25, 1942). The war-related motivation for the antitrust prosecution of the refining patent pools is supported by the testimony of Thurman Arnold, the then-chief of the Antitrust Division, before a Senate committee in 1942. *See supra* note 73 and accompanying text.

129. This refers to a series of pools that were formed to cover multiple cracking processes. In 1921, the Texas and Indiana Standard Oil companies had pooled their patents; in 1923, the Gasoline Products Company and Texas Standard Oil companies had pooled their patents; and separately, the Indiana, Texas and New Jersey Standard Oil companies had pooled their patents. *See Standard Oil Co. (Indiana)*, 33 F.2d at 617, 626–28. For discussion, see ENOS, *supra* note 122, at 119–21; GEORGE SWEET GIBB & EVELYN H. KNOWLTON, HISTORY OF STANDARD OIL COMPANY (NEW JERSEY): THE RESURGENT YEARS 1911–1927 547–59 (1956).

130. *See Hydrogenation Process Shared: Major Oil Refiners Hold Participation in New Hydro Patents Company*, WALL ST. J., July 14, 1930, at 12; *Documents and Agreements Defining and Relating to the Mutual Licensing Plan of Hydro Patents Co. for the Hydrogenation Process, as amended July 1, 1935 in App. to Pooling of Patents: Hearings on H.R. 4523 Before the H. Comm. on Patents*, 74th Cong. 3776–3812 (1935).

131. *See Escrow Agreement, Deposit Agreement, Purchase and Cross-Licensing Agreement, License Agreement (1933) in Pooling of Patents: App. to Hearings on H.R. 4523 Before the H. Comm. on Patents*, 74th Cong. 3733 (1935).

132. *See An Agreement re "H.C. Technique" (Oct. 27, 1933) in Pooling of Patents: App. to Hearings on H.R. 4523 Before the H. Comm. on Patents*, 74th Cong. 3704–17 (1935).

133. *See License Agreement re Fractional Distillation (Mar. 28, 1934) in Pooling of Patents: App. to Hearings on H.R. 4523 Before the H. Comm. on Patents*, 74th Cong. 3698–701 (1935).

134. *See An Agreement re Gas Polymerization Processes (Sept. 1, 1935) in Pooling of Patents: App. to Hearings on H.R. 4523 Before the H. Comm. on Patents*, 74th Cong. 3701–04 (1935).

135. *See Analysis of the Hydrocarbon Synthesis Agreements in Hearings on S. 2303 and S. 2491 Before the S. Comm. on Patents*, 77th Cong., 2d Sess. 3800–07 (1942).

Dispersed patent holdings in the petroleum refining industry did not give rise to transactional chaos, exorbitant royalty demands, or stilted development. Patent holders and manufacturing licensees used contracting structures to preempt or resolve patent litigation and to support continuous investment in technological improvement in the pursuit of increased efficiency. Even during the period of intense patent litigation, the market displayed the symptoms of a healthy innovation environment: vigorous competition for market share by different process providers,[137] dramatically accelerating research and development expenditures on new refining processes,[138] declining royalty rates, and steady technological advance. From 1913 to 1955, the royalty rate assessed on dominant cracking technologies declined from seventeen cents to four cents per barrel and declined as a percentage of total costs from 8.8% to 1.2%.[139] From 1913 through 1938, technological improvement translated into increases in the unit capacity of commercial cracking units from 88.5 barrels per day to 6,750 barrels per day.[140]

Three reasons lie behind these positive outcomes. First, parties with overlapping patent claims had an interest in reaching mutually agreeable licensing terms to allow all parties to enjoy a portion of the resulting surplus value. Second, even secure patent positions over a particular processing technology did not necessarily translate into market power so long as refiner licensees had access to alternative process technologies or had the capacities to develop alternative technologies. Both of these conditions were often met.[141] Even in cases where patent protection did confer some degree of market power, that position could be eroded as high royalty rates induced sophisticated licensees or other third parties to develop alternative processing technologies.[142] Third, one of the principal patent holders was a standalone R&D firm, which did not maintain an independent refining operation and therefore had an interest in offering reasonable royalty

136. *See Alkylation Agreement (Apr. 12, 1939) in Hearings on S. 2303 and S. 2491 Before the S. Comm. on Patents*, 77th Cong., 2d Sess. 3874–92 (1942).

137. Seven major processes were available during 1927–1936. *See* ENOS, *supra* note 122, at 186 tbl.1b.

138. For data on research and development investments, see *id.* at 221, 238.

139. *See id.* at 245, tbl.9. For detail on reductions in the royalty rate for the "Dubbs" process, see *id.* at 91.

140. *See id.* at 241, tbl.7.

141. On competing process technologies that existed over time in the refining industry, see *id.* at 239, 241, 261. For an example in which oil companies cooperated to develop an alternative cracking process and avoid paying royalties to the firm that held a patent with respect to the existing cracking process, see *id.* at 196–97.

142. This was the fate of Indiana Standard, which held the patents to the Burton process, the dominant cracking process from 1913–1919. *See id.* at 57. And the same fate befell the Houdry Process Corporation, whose high royalty demands with respect to the Houdry cracking process induced some of its potential licensees to develop the Fluid Catalytic cracking process. *See id*. at 195–96.

rates that maximized its licensing base.[143] To foster adoption, the R&D firm licensed its patented method (together with know-how and technical assistance) throughout the industry, including to small refiners that did not have R&D capacities.[144] Following that firm's example, the industry ultimately converged on a norm by which patented process technology, together with know-how, was made available to all interested parties (subject to the royalty fee), irrespective of geography or size.[145]

3. The New Patent Intermediaries: ICT Markets

ICT markets seem prone to AC effects. End products often consist of hundreds or even thousands of components and, as a result, it is often difficult to identify the multiple entities that may hold patents over them. Further, in the event of an infringement claim, there is no inexpensive design-around to eliminate or limit liability exposure.[146] Nonetheless, as indicated earlier, information technology markets have largely defied the gloomy expectations of the AC thesis.[147] The pattern is familiar: markets have made organizational innovations to preempt or mitigate AC effects. Two types of mechanisms can be observed: standard-setting organizations and patent pools.

A. Standard-Setting Organizations

Market actors have participated in the formation and operation of hundreds of standard-setting organizations ("SSOs"). These organizations both coordinate the selection of a particular technology standard and subject participants to licensing commitments designed to mitigate the hold-up problems and other transactional frictions associated with AC effects.[148] These entities are responsible for the interoperability that pervades the world of consumer electronics — for example, standard-setting explains why DVDs work in players made by any manufacturer (thank DVD standard-setting consortia), why any sound system can "understand" the Bluetooth signals transmitted by any smartphone (thank Bluetooth standard-setting consortia), and why any laptop can operate seamlessly with a Wi-Fi system in any coffee shop,

143. *See id.* at 92.

144. *See id.* at 92–93, 95.

145. *See id.* at 246.

146. *See* Terry Ludlow, *Trends in Technology IP Licensing*, IPO L.J. 3 (2014), http://www.ipo.org/wp-content/uploads/2014/12/IPLicensingTrends_TerryLudlow1.pdf [http://perma.cc/F7VN-VZ8J] (noting that, given the number of patents that typically apply to an electronic device, it is not feasible to design around all of them).

147. *See supra* Part III.A.1.

148. *See, e.g.*, Mark A. Lemley, *Intellectual Property Rights and Standard-Setting* Organizations, 90 CAL. L. REV. 1889, 1892–94 (2002).

airport or other space (thank the Wi-Fi Alliance).[149] The ubiquity of standards, however, exposes manufacturers and other firms who rely on those standards to hold-up behavior by entities that subsequently assert patents with respect to some difficult-to-substitute component of those standards. To protect against this risk, SSOs typically require that participants agree to disclose all patents that are "essential" to the standard and to license out all "standard-essential" patents on a "reasonable and non-discriminatory" ("RAND") basis.[150] However, the effectiveness of these requirements is limited by the lack of any objective definition of "essential" and "RAND," as well as difficulties in tracking compliance with the RAND commitment.[151]

B. Patent Pools

Patent pools improve upon the limitations of standard-setting entities by providing licensees with a well-defined package of licensing terms and a clear party against whom to bring legal action in the event those terms are breached. As shown in Table 2 below, since the antitrust agencies released guidelines in 1995 that relaxed decades-old constraints on patent licensing,[152] patent holders in technology markets have entered into at least thirty-eight formal multi-lateral cross-licensing arrangements that facilitate access to the patents corresponding to a given technology standard.[153] In some cases, these arrangements have been formed by small numbers of leading patent holders, such as the CD-standard consortium led by Philips in the early 1990s and the competing DVD3C and DVD6C standards consortia that emerged in the late 1990s under the leadership of Philips and Toshiba, respectively.[154] In most cases, however, these arrangements have been implemented by third-party organizational entrepreneurs who evident-

149. For a detailed list of standard-setting organizations in ICT markets, see Barnett, *Patent Networks*, *supra* note 43, at 12–13 tbl.2 (2014).

150. *See* Joseph S. Miller, *Standard Setting, Patents, and Access Lock-In: RAND Licensing and the Theory of the Firm*, 40 IND. L. REV. 351, 353 (2007).

151. *See* Barnett, *Patent Networks*, *supra* note 43, at 8–10; Jorge L. Contreras, *Fixing FRAND: A Pseudo-Pool Approach to Standards-Based Patent Licensing*, 79 ANTITRUST L.J. 47, 64–65 (2013).

152. *See* DEP'T OF JUST. & FED. TRADE COMM'N, ANTITRUST GUIDELINES FOR THE LICENSING OF INTELLECTUAL PROPERTY, 16–23 (1995).

153. In a companion paper, I document these arrangements comprehensively. *See* Barnett, *Patent Networks*, *supra* note 43, at 48–51. Note that I exclude cross-licensing arrangements involving only two parties in order to distinguish pooling arrangements from the much larger pool of bilateral patent licensing agreements.

154. For discussion of the DVD standards consortia, see Simon den Uijl, Rudi Bekkers & Henk J. de Vries, *Managing Intellectual Property Using Patent Pools: Lessons from Three Generations of Pools in the Optical Disc Industry*, 55 CALIF. MGMT. REV. 31, 37–40 (2013). For further details on the DVD6C consortium, see Letter from Joel I. Klein, Acting Asst. Att'y Gen., Antitrust Div., Dep't of Just., to Carey R. Ramos, Esq. (June 10, 1999), http://www.justice.gov/atr/response-hitachi-ltds-matsushita-electric-industrial-co-ltds-mitsubishi-electric-corporations [http://perma.cc/N7P3-Z4ST].

ly sought to provide a solution to incipient AC problems in market segments populated by large numbers of patent holders, none of whom individually hold a complete package of IP rights over a particular fundamental technology. As shown in Table 2 below, these intermediaries implement licensing arrangements involving tens of licensors and hundreds to thousands of licensees. Those arrangements underlie technologies now ubiquitous in everyday life, such as the DVD, the Blu-Ray disc, smartphones, cable set-top boxes, and online audio and video streaming.[155] Without mutual agreement, even firms with large patent positions in any of these market segments could be blocked, resulting in the classic impasse anticipated by AC theory. As in other markets, this potential threat to technological innovation has induced an actual solution in the form of transactional innovation.

155. For precise details on relevant standard-setting organizations and the corresponding real-world technologies facilitated by those organizations, see Barnett, *Patent Networks*, *supra* note 43, at 12–13, tbl.2.

156. All licensee numbers for "Pools" is current as of July 8, 2014. All licensee numbers for "Consortia" is current as of August 24, 2015, except as indicated below with respect to the Premier-BD consortium. A "starred" entry means that the indicated number of licensees may be an underestimate because the administrator did not specify the complete number of licensees for all its pools.

157. For this purpose, I treat "Promoter Members," the highest class of membership in "Bluetooth SIG," as equivalent to a licensor. Promoter Members are required to enter into reciprocal, royalty-free agreements with respect to "necessary" IP assets relating to Bluetooth technology. *See* Promoters Membership Agreement: Exhibit B (Bluetooth Patent/Copyright License), BLUETOOTH SPECIAL INTEREST GRP., https://www.bluetooth.org/en-us/members/membership-agreements (click on "Promoter License Attachment") [http://perma.cc/9BFA-6L6Y].

158. *See* Uijl et al., *supra* note 154, at 37 tbl.1.

159. *See id.*

Table 2: Patent Pool Intermediaries and Consortia[161] in ICT Markets (1997–Present)[162]

Intermediary Entity	First Formed	Total Pools	Total Licensors	Total Licensees[156]
Pools				
MPEG-LA	1997	12	200	4421
SISVEL	1997	8	35	Approx. 1943*
Sipro Lab Telecom	1998	5	26	Approx. 223*
Via Licensing	2003	8	59	Approx. 1561*
Consortia				
Bluetooth SIG	1998	1	7[157]	27255*
DVD3C (One-Red)	1998	1	4	551[158]
DVD6C	1999	1	9	467[159]
Premier BD	2010	1	6	46*[160]
One-Blue	2011	1	16	60*

156. All licensee numbers for "Pools" is current as of July 8, 2014. All licensee numbers for "Consortia" is current as of August 24, 2015, except as indicated below with respect to the Premier-BD consortium. A "starred" entry means that the indicated number of licensees may be an underestimate because the administrator did not specify the complete number of licensees for all its pools.

157. For this purpose, I treat "Promoter Members," the highest class of membership in "Bluetooth SIG," as equivalent to a licensor. Promoter Members are required to enter into reciprocal, royalty-free agreements with respect to "necessary" IP assets relating to Bluetooth technology. *See* Promoters Membership Agreement: Exhibit B (Bluetooth Patent/Copyright License), BLUETOOTH SPECIAL INTEREST GRP., https://www.bluetooth.org/en-us/members/membership-agreements (click on "Promoter License Attachment") [http://perma.cc/9BFA-6L6Y].

158. *See* Uijl et al., *supra* note 154, at 37 tbl.1.

159. *See id.*

160. Current as of July 23, 2015.

161. As used in this Table, "Pools" refers to patent pools administered by an independent third-party entity that regularly forms and administers pools. "Consortia" refer to "one-off" patent pools administered directly or indirectly by one or more of the contributing members of the pool.

162. A slightly older version of this Table is found in Barnett, *Patent Networks*, *supra* note 43, at 18 tbl.3. All information was sourced from the website for each pool or consortium and is current as of August 24, 2015, except as otherwise indicated below. Note that the numbers of licensors and licensees do not refer to unique licensors and licensees — that is, if a firm is a licensor or licensee in more than one pool administered by the same intermediary, it will be counted multiple times. Note further that I use the definition of "patent pools" set forth previously — namely, any horizontal arrangement in which three or more entities agree to cross-license intellectual property pursuant to a contractual agreement or to aggregate intellectual property assets in a single new entity. For that reason, I do not include certain licensing arrangements that are administered by the entities indicated above and are sometimes described as pools by the administrator or other commentators.

IV. THE "EASY" CASES OF AIRCRAFT AND RADIO DO NOT SUPPORT THE ANTI-COMMONS THESIS

The evidence reviewed above casts serious doubt on the AC thesis. A full review of available evidence, however, must address two widely discussed historical episodes in which IP deadlocks apparently arose between holders of patents over critical technologies: (1) a deadlock among holders of patents to early aircraft technologies and (2) a deadlock among holders of patents to early radio communications technologies. In both cases, the standard account posits that the deadlock was resolved by the government engineering a pooling arrangement among the disputing IP holders. Commentators in the legal, economics, and policy fields extensively cite these historical cases, which in turn often rest on accounts by historians or governmental agencies.[163] It is understandable that such commentators would not undertake the considerable effort required to examine the intricate chain of primary sources on which the standard descriptions of these episodes ultimately rely. In two recent studies, John Howells & Ron Katznelson ("H&K") undertake that task and, in the process, cast doubt on the common understanding of these events.[164] If H&K are correct, even these two well-accepted examples do not illustrate the AC thesis. Given that H&K's assertions depart significantly from standard accounts, I examine this evidence with special care, directly reviewing almost all primary sources cited by H&K,[165] supplemented by other historical scholarship and my own research. I find the evidence supports the view that the standard account both (1) overstates the extent to which innovation was likely delayed as a result of patent-related disputes and (2) understates the extent to which the market was able to independently resolve any deadlock attributable to patent-related disputes. Note that I focus below on the most critical evidence for purposes of assessing the extent to which these historical episodes conform to the AC thesis; the interested reader is advised to consult H&K's publications directly for more detailed accounts and supporting evidentiary detail.[166]

---

163. For academic and policy commentary that refers to the aircraft patent deadlock, see *infra* note 171. For academic and policy commentary that refers to the radio patent deadlock, see *infra* note 212.

164. *See* Howells & Katznelson, *Early Aviation*, *supra* note 16, at 1; Howells & Katznelson, Early Radio, *supra* note 16, at 1.

165. The exception is archival data relating to historical patenting rates in vacuum tube technology. *See infra* note 227.

166. *See* Howells & Katznelson, *Early Aviation*, *supra* note 16; Howells & Katznelson, Early Radio, *supra* note 16.

A. The Aircraft Bottleneck (or Not)

On December 17, 1903, Orville and Wilbur Wright successfully flew an aircraft using the "warped-wing" lateral control mechanism,[167] for which the Wright brothers were granted a patent in 1906.[168] Following the Wrights' breakthrough, Glenn Curtiss designed, produced, and sold aircraft using an alternative lateral control mechanism consisting of hinged wing flaps (or "ailerons").[169] In 1909, the Wright firm ("Wright") sued Curtiss for patent infringement, arguing that the Wright patent covered the Curtiss mechanism.[170] As shown in Figure 6 below, the parties were embroiled in litigation through 1917. Proponents of the standard AC thesis often state that the Wright-Curtiss patent dispute blocked or delayed aircraft production and development until the market was rescued through government intervention that compelled the parties to end the dispute.[171] A paper published by two economists through the Federal Reserve Bank of St. Louis even claims that the Wright brothers blocked innovation "for nearly [twenty] years."[172] As H&K's evidence and the supplementary evidence I describe below demonstrate, the historical record does not support these claims.

---

167. *See* Orville Wright, Diary Entry (Dec. 17, 1903), *in* 1 THE PAPERS OF ORVILLE & WILBUR WRIGHT, 1899–1905, 394, 396 (Marvin W. McFarland ed., 2001); Letter from Octave Chanute to Wilbur Wright (Nov. 17, 1905), *in* 1 THE PAPERS OF ORVILLE & WILBUR WRIGHT, 1899–1905, 526, 526 (Marvin W. McFarland ed., 2001); Letter from Wilbur Wright to Octave Chanute (Dec. 8, 1905), *in* 1 THE PAPERS OF ORVILLE & WILBUR WRIGHT, 1899–1905, 532, 532 (Marvin W. McFarland ed., 2001).

168. U.S. Patent No. 821,393 (issued May 22, 1906). Specifically, the Wright patent covered use of the warped wing mechanism in conjunction with a rudder to maintain stability during flight.

169. *See* DONALD M. PATILLO, PUSHING THE ENVELOPE: THE AMERICAN AIRCRAFT INDUSTRY 16–17 (1998).

170. *See* FRED C. KELLY, THE WRIGHT BROTHERS 288 (1943).

171. *See, e.g.*, NAT'L RESEARCH COUNCIL OF THE NAT'L ACADEMIES, A PATENT SYSTEM FOR THE 21ST CENTURY 26 (Stephen A. Merrill et al. eds., 2004); Joel I. Klein, Acting Asst. Att'y Gen., Antitrust Div., Dep't of Just., Cross-Licensing and Antitrust Law, Address Before the American Intellectual Property Law Association 5 (May 2, 1997), http://www.justice.gov/atr/speech/cross-licensing-and-antitrust-law [http://perma.cc/KSD4-KFEQ] (stating that, as of 1917, the Wright patent "still blocked would-be manufacturers, at least for all practical purposes" (footnote omitted)); HELLER, *supra* note 4, at 30–31 (stating that "gridlock" among patent holders "almost ended flight in its earliest days"); BOLDRIN & LEVINE, *supra* note 4, at 87–88; Lampe & Moser, *supra* note 83, at 2 (stating that the Wright brothers' patent enabled them to "block Curtiss from producing planes" (footnote omitted) and suggesting that production of aircraft surged after the patent dispute was resolved through formation of a patent pool); Mark Lemley, *The Myth of the Sole Inventor*, 110 MICH. L. REV. 709, 726 (2012) ("[t]he Wrights successfully enforced their patent against all alternative aircraft"). For a more qualified view, see Merges & Nelson, *supra* note 85, at 890–91 (stating that "[t]here is good reason to believe that the Wright patent significantly held back the pace of aircraft development"). For a fuller discussion of this literature, see Howells & Katznelson, *Early Aviation*, *supra* note 16, at 3–9.

172. *See* Michele Boldrin & David K. Levine, *The Case Against Patents* 3 (Fed. Res. Bank of St. Louis, Working Paper 2012-035A, 2012) [hereinafter Boldrin & Levine, *Case Against Patents*].

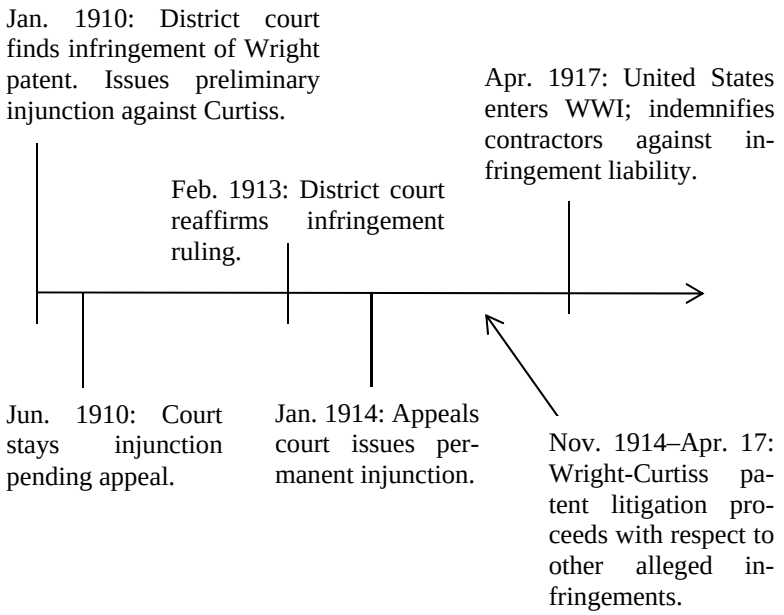

Figure 6: Patent Litigation in Early Aircraft Technologies (1910–1917)

1. Patent Litigation Did Not Discourage Aircraft Production

A single uncomfortable fact casts doubt on the applicability of the AC thesis to the aircraft production dispute. As H&K show, both Curtiss and other aircraft manufacturers were able to legally produce aircraft while the patent dispute was pending.[173] There are two reasons.

First, although Wright secured a preliminary injunction against Curtiss in 1910,[174] Curtiss posted a bond and the preliminary injunction was stayed and then vacated six months later by the appeals court pending final resolution of the case four years later.[175] Historian Timothy Gaffney's account of early aviation observes that, in the wake of the removal of the injunction, the Wright firm "couldn't control the

173. *See* Howells & Katznelson, *Early Aviation*, *supra* note 16, at 10–11, 20.

174. Wright v. Herring-Curtis Co., 177 F. 257, 261 (W.D.N.Y. 1910) (granting preliminary injunction), *rev'd*, 180 F. 110 (2d Cir. 1910).

175. *See* Wright v. Herring-Curtis Co., 180 F. 110 (2d. Cir. 1910); *see also* THE PAPERS OF ORVILLE & WILBUR WRIGHT, *supra* note 167, at 1097–98 n.11 (noting that the Curtiss entity successfully postponed the patent infringement trial until resolution of the dispute through a cross-licensing agreement).

marketplace."[176] The absence of injunctive relief explains why, even as patent litigation proceeded between Wright and Curtiss, a steady flow of new aircraft manufacturers entered the industry: at least twenty-three in 1909; fifty-two in 1910; sixty-four in 1911; forty-three in 1912; twenty-nine in 1913; and nineteen in 1914.[177] Charles B. Hayward's 1912 account of the aeronautical industry observes that the effect of the litigation on the aircraft market seemed to be minimal, apparently due to several factors: (1) the absence of injunctive relief prompted amateur inventors to build airplanes based on the Curtiss design;[178] (2) Wright elected not to pursue litigation against most users of its technology; and (3) Wright, like Curtiss, expressly permitted use of its technology without payment for experimental purposes.[179] The results are palpable: Hayward's account provides a hundred-page-plus catalogue of competing aircraft technologies available during the period of the Wright-Curtiss litigation.[180] Those observations are consistent with patenting data, which shows a spike in aircraft patents during the same period.[181] Even after Wright secured injunctive relief in 1914,[182] Curtiss altered a feature of its aircraft design that had not been litigated in the 1910–1914 litigation, allowing Curtiss to continue production as the litigation proceeded further.[183]

Second, as H&K observe, federal legislation enacted in 1910, and a Supreme Court decision interpreting that legislation in 1914 (the year in which Wright had finally secured some type of injunctive relief), effectively provided that a patentee could not seek injunctive relief (but could seek monetary relief) against the federal government or any contractor retained by the federal government.[184] Since the

176. TIMOTHY R. GAFFNEY, THE DAYTON FLIGHT FACTORY: THE WRIGHT BROTHERS & THE BIRTH OF AVIATION 126 (2014).

177. *See* EATON MFG. CO., A CHRONICLE OF THE AVIATION INDUSTRY IN AMERICA, 1903-1947, at 10–16 (1948). For related observations, see JACOB A. VANDER MEULEN, THE POLITICS OF AIRCRAFT: BUILDING AN AMERICAN MILITARY INDUSTRY 19 (1991) (noting that patent disputes "did not deter new entries"). For discussion of other indicators of industry growth, see Howells & Katznelson, *Early Aviation*, *supra* note 16, at 11–16.

178. *See* CHARLES B. HAYWARD, PRACTICAL AERONAUTICS 703 (1912).

179. *See id.* at 521–22.

180. *See id.* at 197–344.

181. *See* Alex Roland, *Pools of Invention: The Role of Patents in the Development of American Aircraft, 1917-1997*, *in* ATMOSPHERIC FLIGHT IN THE TWENTIETH CENTURY 323, 337–38 figs.1 & 2 (Peter Galison & Alex Roland eds., 2000).

182. *See* Wright v. Herring-Curtis Co., 204 F. 597, 597, 614 (W.D.N.Y. 1913), *aff'd*, 211 F. 654 (2d Cir. 1914).

183. *See* C. R. ROSEBERRY, GLENN CURTISS: PIONEER OF FLIGHT 357–58 (1972); TOM D. CROUCH & PETER L. JAKAB, THE WRIGHT BROTHERS AND THE INVENTION OF THE AERIAL AGE 204 (2003); Herbert A. Johnson, *The Wright Patent Wars and Early American Aviation*, 69 J. AIR L. & COM. 21, 37; TOM D. CROUCH, THE BISHOP'S BOYS: A LIFE OF WILBUR AND ORVILLE WRIGHT 462–63 (1989); Howells & Katznelson, *Early Aviation*, *supra* note 16, at 10–11; George Bittlingmayer, *Property Rights, Progress, and the Aircraft Patent Agreement*, 31 J. L. & ECON. 227, 231 (1988); KELLY, *supra* note 170, at 295–96.

184. *See* Howells & Katznelson, *Early Aviation*, *supra* note 16, at 22–24. As H&K observe, contractors' immunity derived from legislation passed in 1910 that authorized patent-

U.S. military was a major customer for aircraft manufacturers (constituting about 30% of total sales in 1914 and growing to almost 100% by 1917),[185] this was a critical limitation on Wright's litigation threat against the large pool of potential infringers consisting of the federal government and its contractors. Two events illustrate the importance of this limitation. First, as World War I broke out in Europe in 1914, new aviation firms — unconstrained by any injunctive threat — entered the market to satisfy anticipated orders from domestic and foreign militaries.[186] Second, in 1916, the U.S. military entered into its first large aircraft procurement contract, ordering seventy-four planes from the Curtiss Aeroplane and Motor Company, a subsidiary of Wright's key adversary in patent litigation, and none from Wright.[187] During 1909–1917, Wright only sold twenty-six aircraft to the military, whereas Curtiss sold 232.[188] Both developments run contrary to the standard assumption that Wright's patent gave it control over the market. Rather, Wright had lost the market's largest single customer.

A. Non-Legal Factors Account for the Aircraft Industry's Slow Start

Non-legal factors seem to account for the slow initial development of the aviation industry. These factors include: technical difficulties, especially frequent crashes; few landing facilities; limited

---

ees to sue the federal government in the Court of Claims for monetary compensation whenever the federal government used a patented product without authorization. *See* Act of June 25, ch. 423, 36 Stat. 851 (1910) (codified at scattered sections of the U.S. Code). The Act was intended to reverse Supreme Court decisions holding that patentees could not bring an infringement claim against the federal government (on grounds of sovereign immunity), thereby effectively preventing a patentee from seeking any remedy against the government unless it had entered into a contract with the government and could bring a breach of contract action. *See also* Russel v. United States, 182 U.S. 516, 535 (1901); Schillinger v. United States, 155 U.S. 163, 168–69 (1894); United States v. Palmer, 128 U.S. 262, 271–72 (1888). As subsequently interpreted, the 1910 Act prevented patentees from suing government contractors operating pursuant to a procurement contract. *See* Int'l Curtis Marine Turbine Co. v. William Cramp & Sons Ship & Engine Bldg. Co., 211 F. 124, 153 (3d. Cir. 1914). In 1918, however, the Supreme Court held that the Act did not preclude infringement suits against a government contractor. *See* William Cramp & Sons Ship & Engine Bldg. Co. v. Int'l Curtis Marine Turbine Co., 246 U.S. 28, 45 (1918); Marconi Wireless Tel. Co. of Am. v. Simon, 246 U.S. 46, 56–57 (1918). Congress promptly provided otherwise in July 1918, restricting the patentee's remedy in such cases to monetary damages against the government. *See* 28 U.S.C. § 1498(a) (1964). For further discussion, see OFF. OF NAVAL REC. & LIBR. HIST. SEC., NAVY DEP'T, HISTORY OF THE BUREAU OF ENGINEERING NAVY DEPARTMENT DURING THE WORLD WAR 128–30 (1922) [*hereinafter* NAVY DEP'T].

185. *See infra* note 193 and accompanying text.

186. *See* Johnson, *supra* note 183, at 43; HERBERT A. JOHNSON, WINGLESS EAGLE: U.S. ARMY AVIATION THROUGH WORLD WAR I 107–14 (2001) [hereinafter JOHNSON, WINGLESS EAGLE].

187. *See* Johnson, *Wright Patent Wars*, *supra* note 183, at 47; JOHNSON, WINGLESS EAGLE, *supra* note 186, at 110–11.

188. *See* Tom D. Crouch, *Blaming Wilbur and Orville: The Wright Patent Suits and the Growth of American Aeronautics*, *in* ATMOSPHERIC FLIGHT IN THE TWENTIETH CENTURY 287, 291 (Peter Galison & Alex Roland eds., 2000).

manufacturing capacity; small numbers of qualified pilots; and low market demand.[189] Two related facts strongly support this explanation.

First, Wright's lack of commercial success immediately following its invention appears to be largely due to the U.S. military's lack of interest.[190] Wright elicited greater interest from European militaries, which devoted greater funds to military procurement. During 1908–1913, Germany spent $22 million on military aviation, France spent $22 million, Russia spent $12 million, and the United States spent only $430,000.[191]

Second, while aircraft production did surge after resolution of the Wright-Curtiss patent dispute in 1917, that surge coincided with U.S. entry into World War I, a political action accompanied by unprecedented congressional appropriation of funds for aircraft production[192] and a dramatic increase in the U.S. military's aviation personnel from 311 in 1916 to 195,023 in 1918.[193] As shown in Figure 7 below, after the conclusion of World War I, federal appropriations and industry production plunged, with output falling from over 14,000 aircraft in 1918 to 263 in 1922,[194] even though the aviation patent dispute had been resolved. War, not patent litigation, seems to have been the prime driver behind investment in aircraft development and production.

189. *See* G. R. Simonson, *The Demand for Aircraft and the Aircraft Industry, 1907–1958*, 20 J. ECON. HIST. 361, 362, 365 (1960). On limited demand, see generally Howard Mingos, *Birth of an Industry*, *in* THE HISTORY OF THE AMERICAN AIRCRAFT INDUSTRY 25 (G. R. Simonson ed., 1968). On limited government funding, see Crouch, *supra* note 188, at 295–98. On technical difficulties and the limited number of qualified aviators, see ARCHIBALD D. TURNBULL & CLIFFORD L. LORD, HISTORY OF UNITED STATES NAVAL AVIATION 82–83, 93 (1972).

190. *See* Alex Roland, *Model Research: The National Advisory Committee for Aeronautics 1915–1958*, *in* 1 THE NASA HISTORY SERIES 39–40 (1985); TURNBULL, *supra* note 189, at 4, 7, 96.

191. *See* A HISTORY OF THE UNITED STATES AIR FORCE: 1907–1957, at 8 (Alfred Goldberg ed., 1957).

192. *See* VANDER MEULEN, *supra* note 177, at 14.

193. *See* AEROSPACE FACTS AND FIGURES 1963, at 97 (Gerald J. McAllister ed., 1963).

194. *See* Simonson, *supra* note 189, at 365.

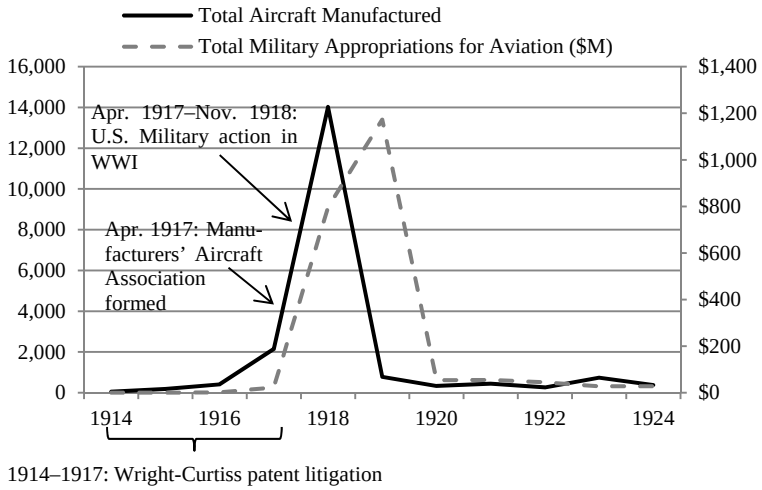

Figure 7: U.S. Aircraft Manufacturing (1914–1924)[195]

B. The Market Solution to the Aircraft Patent Dispute

Commentators typically state that the Wright-Curtiss patent dispute only ended due to government intervention requiring the parties to cease litigation and form a patent pool, thereby putting an end to aggressive litigation by a patentee (Wright) who had "unfairly" blocked innovation in the aircraft industry.[196] This understanding seems consistent with the observed historical sequence: concurrent with U.S. entry into World War I in April 1917, the U.S. military proposed, and the Wright and Curtiss firms agreed to, a cross-licensing arrangement administered by the newly-formed Manufacturers' Aircraft Association (the "MAA").[197] Relying on scholars' interpretation

195. *See* AEROSPACE FACTS AND FIGURES, *supra* note 193, at 6, 99. For a more complete graph that covers similar information, see Howells & Katznelson, *Early Aviation*, *supra* note 16, at 13 fig.1. For discussion, see IRVING BRINTON HOLLEY JR., BUYING AIRCRAFT: MATÉRIEL PROCUREMENT FOR THE ARMY AIR FORCES 10 (1964). Military appropriations for aviation are a close proxy for market demand for aircraft since they accounted for the vast majority of total aircraft sales during this period. From 1915 to 1924, military procurement represented the following annual percentages of total aircraft sales: (1) 30.6% (1914); (2) 14.6% (1915); (3) 34.6% (1916); (4) 93.7% (1917); (5) 99.8% (1918); (6) 87.4% (1919); (7) 78.1% (1920); (8) 89% (1921); (9) 86% (1922); (10) 92.4% (1923); (11) 84.1% (1924). HERMAN O. STEKLER, THE STRUCTURE AND PERFORMANCE OF THE AEROSPACE INDUSTRY 2–5 (1965).

196. *See, e.g.*, HELLER, *supra* note 4, at 30–31; Bittlingmayer, *supra* note 183, at 232.

197. The basic terms were as follows: (1) membership in the pool was open to all "responsible" aircraft manufacturers, who were then obligated to contribute all their present and future aircraft-related patents to the pool; (2) members enjoyed nonexclusive licenses to all aircraft-related patents in the pool; (3) until expiration of the Wright and Curtiss patents, manufacturing members would pay a royalty of $200 per aircraft, of which 67.5% was owed to Wright, 20% to Curtiss and the remainder to the pool for administrative expenses; (4) the total royalties to be received by Wright and Curtiss were capped at $2 million each; and (v)

of the formation of the MAA, a well-known *New Yorker* columnist wrote: "[h]ad Congress not stepped in, we might still be flying around in blimps."[198]

This conventional narrative overlooks two important elements. First, prior to formation of the MAA, the litigants had independently taken efforts to resolve the litigation, as predicted by a nuanced application of the AC thesis. Reportedly, the Wright Company sought to settle the patent dispute in 1916 by merging with the Curtiss Airplane & Motor Company, but the transaction was abandoned due to fear of antitrust risk.[199] Second, as H&K show, the U.S. government's intervention is best interpreted as an effort to reduce the costs the military paid to outside technology providers, rather than any pressing need to rescue the aircraft market from a patent deadlock.[200]

Per H&K's version of events, the government's allegations that Wright was enforcing its patent aggressively and holding back aircraft development were intended to promote military efforts to reduce its aircraft procurement costs.[201] This argument rests on two key observations. First, the government's account seems disingenuous. H&K show that Wright licensed the patent widely,[202] and contemporary accounts reported that Wright had announced its intention to maintain that policy.[203] Second, and most critically, the military possessed hold-up power given the lucrative revenues to be earned by aircraft manufacturers through wartime procurement, the unavailability of injunctive relief, and Congressional authorization to completely or partially expropriate the Wright and Curtiss patents. The conventional narrative simply does not appreciate the balance of power in the relationship between the military and Wright. Wright did not exert any credible hold-up threat against the government given Wright's inability to seek injunctive relief, while the government could divert procurement contracts to other manufacturers. In short, the government

---

an arbitration mechanism would be used to assess royalties for "exceptional" patents contributed to the pool, while all other patents would be made available on a royalty-free basis. *See* Mfrs. Aircraft Ass'n v. United States, 77 Ct. Cl. 481, 486–87, 489–90 (1933); Bittlingmayer, *supra* note 183, at 232–34; ROLAND, *supra* note 190, at 40–41.

198. James Surowiecki, *The Permission Problem*, NEW YORKER, Aug. 11, 2008, at 1 (referring to government's intervention to create aircraft patent pool).

199. *See* VANDER MEULEN, *supra* note 177, at 19. In 1929, the two firms merged, creating the Curtiss-Wright Corporation. *See* Andrew J. Waskey, *Aircraft Manufacturing*, *in* ENCYCLOPEDIA OF TRANSPORTATION: SOCIAL SCIENCE AND POLICY 68, 70 (Mark Garret ed., 2014).

200. *See* Howells & Katznelson, *Early Aviation*, *supra* note 16, at 20.

201. *See id.* at 20–22.

202. *See id.* at 11.

203. *See* HAYWARD, *supra* note 178, at 521–22 (citing statement attributed to counsel for Wright).

could wait for the patentees to conclude the litigation, but the patentees could not.[204]

Specifically, Wright and Curtiss did not exert a credible hold-up threat given the unavailability of injunctive relief under the 1910 legislation described above.[205] Effectively, this legislation and its judicial interpretations entitled the government and its contractors to a compulsory license at a rate to be determined through a costly and lengthy judicial process in the Court of Claims.[206] By contrast, the military did exert a credible hold-up threat given a 1917 appropriations bill that empowered the military to secure, by purchase or condemnation, patents "necessary to the manufacture and development of aircraft in the United States for governmental and civil purposes" and appropriated $1 million for that purpose.[207] Consistent with a government hold-up theory, Wright and Curtiss agreed to the cross-licensing arrangement shortly after passage of this bill,[208] and their agreement resulted in a reduced aggregate royalty rate relative to the patentees' prior rate demands.[209] After the manufacturers commenced wartime production, the government and the MAA renegotiated a further rate reduction, which halved the royalty granted to Wright and Curtiss and capped the total royalty amount to which those firms were entitled.[210] In correspondence sent in connection with that renegotiation, the Secretary of the Navy reminded the MAA that Congress had appropriated $1 million for purposes of a compulsory purchase of the Wright and

---

204. *See Hearing on H.R. 4523 Before the H. Comm. on Patents*, 74th Cong. 10 (1935) (statement of William Mitchell, Brig. Gen., quoting contemporary speech by Rep. John M. Nelson, stating that the MAA was approved by the government at a time when "it was not a serious crisis for the Government, it was merely a serious crisis for two airplane companies that were fighting over patents on which they wanted to collect from the Government").

205. *See* Howells & Katznelson, *Early Aviation*, *supra* note 16, at 22–23. For the statute, see Act of June 25, ch. 423, 36 Stat. 851 (1910) (codified at scattered sections of the United States Code).

206. *See* Howells & Katznelson, *Early Aviation*, *supra* note 16, at 22–23.

207. *See* ACT OF MARCH 4, 1917, c. 180; Tit. 17A, § 3115 1/32f, *in* UNITED STATES COMPILED STATUTES, ANNOTATED, 1916 (West Publishing Co. 1920).

208. *See* Roland, *supra* note 181, at 326.

209. *See* Bittlingmayer, *supra* note 183, at 233. Based on press coverage, the Wright-Martin company had previously demanded any manufacturer to pay a five percent royalty, subject to a minimum guaranteed amount of $10,000. *See $10,000 a Year for a Wright License*, N.Y. TIMES, Dec. 19, 1916, at 20. By comparison, the MAA cross-licensing agreement provided for a royalty of $200 per plane, subject to an aggregate cap of $2 million each over the life of the agreement for Wright and Curtiss. *See* Mfrs Aircraft Ass'n v. United States, 77 Ct. Cl. 481, 487 (1933); Bittlingmayer, *supra* note 183, at 232–33; ROLAND, *supra* note 190, at 40–41.

210. For the renegotiated agreement between the government and the MAA, see *First Supplemental Cross-License Agreement (April 19, 1918) in Pooling of Patents: App. To Hearings on H.R. 4523 Before the H. Comm. on Patents*, 74th Cong. 10, at 3070–72 (1935); *see also Mfrs. Aircraft Ass'n*, 77 Ct. Cl. at 489–90. After the war, the government apparently sought to evade paying any royalty by diverting production to non-member manufacturers. Litigation ensued between the MAA and the government, which ultimately paid addi-additional royalties on aircraft manufactured by third parties for the military. *See id.* at 498–99.

Curtiss patents.[211] Following this account, it was the government, rather than the patentees, who engaged in hold-up.

B. The Radio Bottleneck (or Not)

To illustrate AC effects, academic and policy commentators often refer to the bargaining deadlock that emerged in the early 20th century among the major holders of patents over certain key technologies in the nascent radio (or, as it was then known, "wireless") communications industry.[212]

1. Blocking Patents (or Not)

The Marconi firm, founded by industry pioneer Gugliemo Marconi, was the leading provider of wireless telegraphic communication for commercial maritime purposes, the initial application for radio communications, from the inception of the industry in the late 1890s. Marconi's position was secured in part by the "Fleming" patent (issued in 1905 and later acquired by Marconi), which claimed a two-element vacuum tube, or diode, for purposes of detecting radio waves.[213] A competing innovator, Lee De Forest, threatened Marconi's position by developing the triode valve (a three-element vacuum tube), marketed as the "Audion" device and protected by various patents.[214] The Audion was initially used as a radio wave detection device, but was recognized in 1912 as a revolutionary advance in both amplifying radio signals and generating a continuous stream of electromagnetic waves for radio transmission as an oscillator.[215] This oscillation property meant that De Forest's vacuum tube could operate as a receiver, amplifier, and transmitter of radio waves. The latter function proved critical in enabling the development of continuous wave radio apparatuses suitable for transmitting voice and sounds,

---

211. *See Mfrs. Aircraft Ass'n*, 77 Ct. Cl. at 489–91.

212. *See, e.g.*, NAT'L RES. COUNCIL OF THE NAT'L ACADEMIES, A PATENT SYSTEM FOR THE 21ST CENTURY 26 (Stephen A. Merrill et al. eds., 2004); Roberto Mazzoleni & Richard R. Nelson, *The Benefits and Costs of Strong Patent Protection: A Contribution to the Current Debate*, 27 RES. POL'Y 273, 280 (1998); Robert P. Merges, *Intellectual Property Rights and Bargaining Breakdown: The Case of Blocking Patents*, 62 TENN. L. REV. 75 (1994); Lemley, *supra* note 171, at 727–28; Merges & Nelson, *supra* note 85, at 891–93; Boldrin & Levine, *supra* note 172, at 3; Alexander Tabarrok, *Patent Theory Versus Patent Law*, 1 CONTRIBUTIONS TO ECON. ANALYSIS & POL'Y 1, 13 n.20 (2002).

213. *See* U.S. Patent No. 803,684 (issued Nov. 7, 1905); Leonard S. Reich, *Research, Patents and the Struggle to Control Radio: A Study of Big Business and the Use of Industrial Research*, 51 BUS. HIST. REV. 208, 211 (1977).

214. *See, e.g.*, U.S. Patent No. 841,387 (issued Jan. 15, 1907); U.S. Patent No. 879,532 (issued Feb. 18, 1908).

215. *See* HUGH G. J. AITKEN, THE CONTINUOUS WAVE: TECHNOLOGY AND AMERICAN RADIO, 1900–1932, at 224, 228, 236 (1985); W. RUPERT MACLAURIN, INVENTION & INNOVATION IN THE RADIO INDUSTRY 77 (1949).

rather than telegraphic communications.[216] As observed by the Supreme Court, referring to the Audion: "The device established itself almost at once as a revolutionary improvement in the art of transmitting sounds at great distances . . . ."[217]

In 1915, the Marconi firm brought a patent infringement suit against the De Forest firm, claiming that the triode infringed upon the Fleming patent relating to Marconi's diode valve.[218] In response, De Forest counterclaimed for patent infringement by Marconi.[219] In 1916, the court held that De Forest's use of the Audion had infringed upon certain claims of Marconi's diode patent, acknowledged that Marconi had "confessed" to having infringed certain of De Forest's claims, and dismissed De Forest's infringement counterclaims against Marconi.[220]

This state of affairs is typically described as a "blocking patents" scenario. The pioneer (Marconi) could not improve its two-element vacuum tube technology given the improver's patents on the triode, as acknowledged by Marconi's "confession." The improver, De Forest (and AT&T, to which De Forest had assigned some of the patent rights relating to the Audion),[221] could not exploit its technology given the pioneer's patents on the diode, as determined by the court.[222] H&K dispute this interpretation on the ground that the court had specifically held that Marconi's patent claims captured the detection functions of De Forest's Audion. This implied that De Forest could pursue the Audion's more commercially significant amplification and oscillation functions.[223] Unsurprisingly, this was the interpretation

---

216. For explanation, see TOM LEWIS, EMPIRE OF THE AIR: THE MEN WHO MADE RADIO 69–74 (1991); Radio Corp. of Am. et al. v. Radio Eng'g Labs., Inc., 293 U.S. 1, 10–12 (1934).

217. *Radio Corp. of Am.*, 293 U.S. at 11.

218. *See* Reich, *supra* note 213, at 216; U.S. Patent No. 803,684 (issued Nov. 7, 1905). This lawsuit was preceded by other litigation between the parties. As early as 1904, De Forest had sued Marconi for patent infringement. *See Two Suits Against Marconi Wireless Co.*, N.Y. TIMES, July 3, 1904, at 8.

219. *See* Marconi Wireless Tel. Co. of Am. v. De Forest Radio Tel. & Tel. Co., 243 F. 560, 565–66 (2d Cir. 1917).

220. *See* Marconi Wireless Tel. Co. of Am. v. De Forest Radio Tel. & Tel. Co., 236 F. 942, 943 (S.D.N.Y. 1916).

221. AT&T purchased various rights to De Forest's triode patent in 1913, 1914, and 1917. De Forest retained rights to make and sell radio equipment to amateur users, to make and sell radio equipment to the U.S. government, and to make and sell apparatuses for the transmission and reception of news and music. *See* AITKEN, *supra* note 215, at 246–47; GLEASON L. ARCHER, HISTORY OF RADIO TO 1926, at 135–36 (1938); N. R. DANIELIAN, AT&T: THE STORY OF INDUSTRIAL CONQUEST 105 (1939); MACLAURIN, *supra* note 215, at 85.

222. *See* MACLAURIN, *supra* note 215, at 85; GERALD F. J. TYNE, SAGA OF THE VACUUM TUBE 126 (1977). For a more complete description of the literature, see Howells & Katznelson, Early Radio, *supra* note 16, at 2–4.

223. *See* Howells & Katznelson, Early Radio, *supra* note 16, at 12–13. For similar views, see AITKEN, *supra* note 215, at 223 (noting that Fleming's patent only reasonably captured "its use as a detector").

adopted by De Forest, as evidenced by its advertising materials.[224] A review of the sequence of judicial orders and decisions issued over the course of the Marconi-De Forest litigation validates H&K's view.[225]

While H&K's argument is well grounded in the judicial record, it relies on the ability of market participants to appreciate the fine legal distinctions set forth in the flow of court orders and decisions. Even if the market appreciated those distinctions, it might still be reasonably argued that the uncertainty created by the Marconi-De Forest patent litigation caused a chilling effect that discouraged investment in wireless communications technology. As discussed further below, howev-

224. During the appeals process, the De Forest firm altered its advertising so that it referred to the Audion solely as an amplifier and transmitter, rather than as a detector. *See* ALAN DOUGLAS, RADIO MANUFACTURERS OF THE 1920'S 160 (1988). After World War I, De Forest independently manufactured and sold "Oscillions," taking the view that applying the triode technology to produce power oscillators, rather than a detection device, fell outside the scope of the Marconi patent. *See* TYNE, *supra* note 222, at 129.

225. H&K's account is consistent with the district court opinion, which focuses on the detection functions of the Fleming valve, as well as Marconi's concession that it had infringed upon certain of De Forest's patents relating to the amplification and oscillation properties of the triode valve. *See* Marconi Wireless Tel. Co. of Am. v. De Forest Radio Tel. & Tel. Co., 236 F. 942 (S.D.N.Y. 1916). However, H&K's account requires one correction. In July 1917, the district court did modify the permanent injunction (issued in May 1917) to clarify that it applied more broadly to use of the diode as an "amplifier[]," although not as an "oscillion[]." *See* Marconi Wireless Tel. Co. of America v. De Forest Radio Tel. & Tel. Co., 236 F. 942 Docket No. 12-31 at 491 (S.D.N.Y. 1916) (obtained from National Archives, on file with author). As subsequently noted, this expanded injunctive relief had no practical effect since the government effectively abrogated all patent rights over wireless technology upon the entry of the United States into World War II in April 1917. *See* MACLAURIN, *supra* note 215, at 85; TYNE, supra note 222, at 126. H&K do note that a later court decision found that De Forest's "Oscillion" device also infringed upon the Fleming patent. *See* Howells & Katznelson, Early Radio, *supra* note 16, at 15; *see also* Marconi Wireless Tel. Co. of Am. v. De Forest Radio Tel. & Tel. Co., 261 F. 393, 395 (S.D.N.Y. 1919). However, a subsequent court decision reinstated De Forest's more narrow interpretation of the Fleming patent. *See* Radio Corp. of Am. v. Radio Audion Co., 278 F. 628 (D. Del. 1922) (holding that the Fleming patent had been violated by the De Forest triode when used for detection purposes, but not when used for amplification purposes). When assessing any potential AC effects relating to these litigations, both the 1919 and 1922 decisions are practically moot since any patent roadblock had been removed by the formation of the Radio Corporation of America pooling entity in 1920, as discussed subsequently. In 1935, the Court of Claims found that use of the De Forest triode for amplification and oscillation purposes fell outside the scope of the diode patent and observed additionally that even the detection function of the De Forest audio device (as used by the U.S. Navy) did not fall within the scope of the detection function claimed by the Fleming patent. *See* Marconi Wireless Tel. Co. of Am. v. United States, 81 Ct. Cl. 671, 735, 737 (1935) (stating that "[t]he Fleming tube does not possess any inherent ability to generate radio oscillations or to amplify them" and that the De Forest three-element vacuum tube "when used as a detector . . .operate[s] in a different manner" from the use of the two-element vacuum tube as claimed in the Fleming patent). Finally, it should be noted that extensive litigation took place between De Forest and other patent holders disputing invention priority with respect to use of the vacuum tube as an oscillation device. In 1934, the Supreme Court decided this in De Forest's favor. *See* Radio Co. of Am. et al. v. Radio Eng'g Labs. Inc., 293 U.S. 1, 14 (1934). However, much of the scientific community and at least some historians disagree with the decision. *See* MACLAURIN, *supra* note 215, at 119–23; LEWIS, *supra* note 216, at 71–88. I have not found evidence that these interference disputes resulted in any injunctive order against use of the vacuum tube for oscillation purposes.

er, those concerns can be comfortably set aside in light of two observations. First, historical trends in the growth of the radio communications markets were almost certainly driven by non-patent tech-technological, political, and business factors — most importantly, as in the case of the Wright-Curtiss patent dispute in aircraft technology, the entry of the United States into World War I. Second, patent holders took action to address any prospective or actual patent deadlock through cross-licensing arrangements that enabled development and production to proceed despite ongoing infringement litigation. The combination of these factors strongly indicates that the Marconi-De Forest patent litigation most likely had little adverse effect on the early development of wireless communication technology.

2. 1906–1915: The Relative Unimportance of Patent Litigation in Early Radio Communications

The standard account claims that the Marconi-De Forest litigation delayed innovation and implementation of wireless communications technologies. That implies that those technologies would have immediately experienced widespread adoption but for the burden imposed by patent litigation. This view suffers from two infirmities. First, it ignores the fact that the full ramifications of the invention of radio — in particular, its broadcasting capacities for music and news — were not immediately appreciated[226] and that early radio apparatuses suffered from technical difficulties.[227] Hence, even in a world without legal frictions, it is not clear that radio technology would have been adopted and developed any faster. Second, as H&K argue, this view is incompatible with evidence that sales of the triode by De Forest and other entities grew even as the litigation continued.[228] Using archival data, H&K also show that technological development, as indicated by patenting rates in vacuum tube electronics, advanced throughout the same period.[229]

---

226. *See* ARCHER, *supra* note 221, at 93–94, 112–13; *see also* Robert H. Marriott, *United States Radio Development*, 5 PROC. OF THE INST. RADIO ENG'R 179, 192 (1917) (stating that "[i]n the earlier history . . .the public as a whole apparently regarded radio as more or less of a scientific toy").

227. *See, e.g.*, ARCHER, *supra* note 221, at 107, 133 (noting technical difficulties in using the Audion triode for purposes of land-wire telephony and problems with interference in wireless telephony); LINWOOD S. HOWETH, HISTORY OF COMMUNICATIONS-ELECTRONICS IN THE U.S. NAVY 373 (1963) (noting the Navy's dissatisfaction with performance of radio equipment supplied by private contractors and the decision in 1913 to begin designing and producing radio equipment).

228. *See* Howells & Katznelson, Early Radio, *supra* note 16, at 6 fig.2, 8. For the primary source, see Tyne, *supra* note 222, at 108–11 tbl.7-1, 130–31 (documenting sales of thousands of Audions from 1914–1918 by De Forest Radio Telegraph and Telegraph Company and McCandless).

229. *See* Howells & Katznelson, Early Radio, *supra* note 16, at 7 fig.3.

Other indications of market growth are consistent with the view that patent litigation had no chilling effect. Figure 8 below shows that the number of wireless stations and transmission ranges increased dramatically after 1911 and was apparently unaffected by the start of the Marconi-De Forest litigation in 1914 or Marconi's victory at the district court in 1916. These growth trends coincide with several non-patent factors: (1) the recognition in 1912 of the triode's amplification and oscillation properties;[230] (2) the enactment in 1911 of legislation requiring the installation of wireless equipment on certain types of ships;[231] and (3) the entry of the United States into World War I in 1917. As I discuss further below, these non-legal factors provide a far more persuasive explanation for market trends in the wireless communications market than any transactional frictions potentially attributable to the ongoing patent litigation.

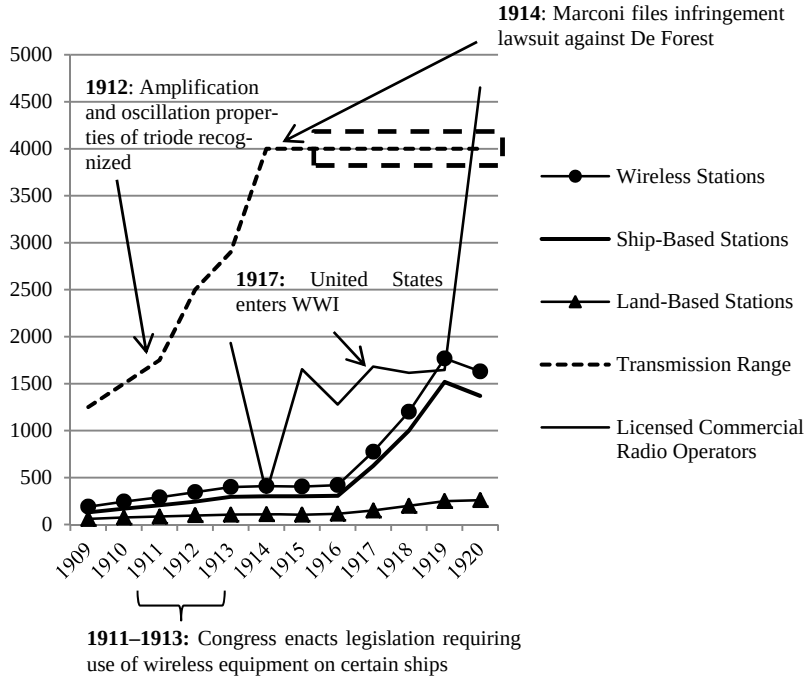

Figure 8: Growth Indicators in Wireless Communications Market (1909–1920)[232]

230. *See supra* note 221 and accompanying text.

231. The principal legislation was the Wireless Ship Act of 1910, which went into effect in 1911. *See* Elizabeth Kruse, *From Free Privilege to Regulation: Wireless Firms and the Competition for Spectrum Rights Before World War I*, 76 BUS. HIST. REV. 559, 695 (2002). For further discussion, see HOWETH, *supra* note 227, at 158–65.

232. Note that "wireless stations" encompasses both land-based and ship-based stations. For data on transmission ranges, see Marriott, *supra* note 226, at 182 chart 2. For data on

3. 1916–1918: Why Patent Litigations Did Not Impede Innovation in Radio

The standard account asserts a causal connection between the Marconi-De Forest patent dispute and an allegedly delayed rate of innovation. But there is one problem with this account. As H&K show, there is no period of time during which that litigation ever resulted in an injunction that effectively blocked use of the Audion in radio communications technology.[233] In September 1916, the district court upheld Marconi's infringement claim, and in October 1916, the court reportedly issued an injunction.[234] The docket for the case shows, however, that the injunction was dead on arrival: it was immediately suspended because De Forest posted a bond pending appeal and agreed to provide periodic accounting reports pending a final adjudication.[235] In May 1917, the appeals court upheld the district court's rulings and issued a permanent injunction.[236] But that affirmance was already moot. In April 1917, the United States entered World War I, at which time the federal government prohibited commercial private wireless operations,[237] assumed control of private wireless stations,[238] and, in 1918, modified procurement contracts to provide that the government would hold and save harmless any contractor sued for patent infringement.[239] Given those assurances, mili-

---

wireless stations, see THORN L. MAYES, WIRELESS COMMUNICATION IN THE UNITED STATES: THE EARLY DEVELOPMENT OF AMERICAN RADIO OPERATING COMPANIES 18 fig.2, 20 fig.3 (1989). For data on commercial licensed radio operators, see HIRAM L. JOME, ECONOMICS OF THE RADIO INDUSTRY 82 tbl.12 (1925). Note that the data for transmission ranges and wireless stations is approximate because the sources present the data in graph form without specifying the precise value of the underlying figures. The dashed box that surrounds a portion of the line for transmission ranges reflects the fact that data is not available for that time period. I have conservatively assumed that transmission ranges neither increased nor declined during this time.

233. *See* Howells & Katznelson, Early Radio, *supra* note 16, at 12–13.

234. *See Enjoins Marconi Company: Restrained from Using Audio Detector Owned by De Forest Co.*, N.Y. TIMES, Oct. 14, 1916, at 16.

235. *See* Marconi Wireless Tel. Co. of America v. De Forest Radio Tel. & Tel. Co., 236 F. 942 Docket No. 12-31 at 491 (S.D.N.Y. 1916) (obtained from National Archives, on file with author) (On Oct. 20, 1916 De Forest posted a $3000 bond and on Nov. 2, 1916 the company posted an additional $2000 bond.). The docket further indicates that Marconi sought to reinstate the injunction due to De Forest's failure to comply with a prescribed reporting procedure; however, the motion was denied on Jan. 20, 1917 once De Forest supplied the required report. *See id.* at 501. Suspension of the injunction explains why De Forest apparently used his technology in the intervening months to make widely-publicized broadcasts of music and news. *See Columbia Used to Demonstrate Wireless Telephone*, THE MUSIC TRADE REV., Nov. 4, 1916, at 52; *Air Will Be Full of Music To-night*, N.Y. SUN, Nov. 6, 1916; *Dance to Wireless Music 40 Miles Off*, N.Y. TIMES, Dec. 31, 1916, at 4.

236. *See* Marconi Wireless & Tel. Co. v. De Forest Radio Tel. & Tel. Co., 243 F. 560, 560 (2d Cir. 1917).

237. *See* ARCHER, *supra* note 221, at 137, 1142–43.

238. *See* AITKEN, *supra* note 215, at 286.

239. *See* John B. Brady, *The Relation of Patents to Radio Manufacturing*, 5 J. PAT. OFF. SOC'Y 268, 276 (1922). The government's indemnification commitment was intended to

tary contractors ignored third-party patent claims and, under military procurement contracts, freely manufactured vacuum tubes for radio apparatuses.[240] Congressional hearings held in 1919 on the radio communications industry observed that "the Government, in operating wireless, can at any time take and use patents and settle with the owners at a later date . . . ."[241] Until the end of the war in November 1918, the industry effectively operated under a mandated pooling arrangement subject to a royalty rate payable at some future date by the government.

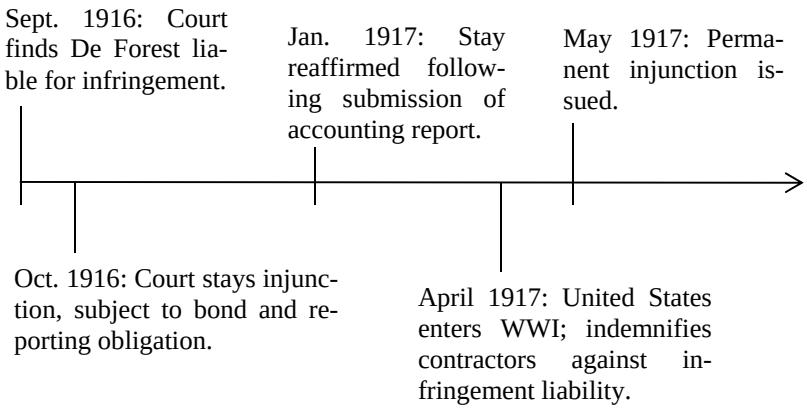

Figure 9: Patent Litigation in Early Radio Communications Technologies (1916–1917)

4. 1918–1921: How the Government Intervened to Adjust Market Resolution of Patent Deadlock

After World War I ended, it was expected that the government would restore private ownership of wireless apparatuses[242] and civil-

reassure contractors in the wake of Supreme Court decisions that had held that patentees could sue government contractors for patent infringement. *See* William Cramp & Sons Ship & Engine Bldg. Co. v. Int'l Curtis Marine Turbine Co., 246 U.S. 28, 45 (1918), *superseded by statute*, Act of July 1, 1918, 40 Stat. 705 (codified as 28 U.S.C. §1498(a) (1964)), *as recognized in* Richmond Screw Anchor Co. v. United States, 275 U.S. 331, 343 (1928); Marconi Wireless Tel. Co. v. Simon, 246 U.S. 46, 57 (1918). A few months later, Congress passed legislation providing that, in alleged infringement involving government procurement contracts, the patentee's remedy was restricted to monetary damages against the government. *See* 28 U.S.C. § 1498(a) (1964). For further discussion, see Howells & Katznelson, Early Radio, *supra* note 16, at 12–13.

240. *See* NAVY DEP'T, *supra* note 184, at 129–30.

241. *See Use of Naval Radio Stations for Commercial Purposes: Hearing Before a Subcomm. of the S. Comm. on Naval Affairs*, 66th Cong. 93 (1919) [hereinafter *Radio Station Hearings*] (posed as a question by a Senator to a U.S. Navy representative, who responded in the affirmative).

242. In February 1919, the federal government removed the ban on the use of wireless apparatuses on commercial vessels. *See* MAYES, *supra* note 232, at 115. In July 1919, Con-

ian markets for radio communications would re-emerge, resulting in renewed patent deadlock.[243] This is the point at which commentators typically state that the patent holders were stuck and had to be rescued by government intervention acting in the public interest.[244] As H&K emphasize, this overlooks a simple fact: the leading patent holders had already rescued themselves from any such deadlock.[245] In April 1919, Marconi and De Forest had independently reached an agreement by which a third party assembled vacuum tubes for De Forest and transferred them to Marconi for distribution.[246] In October 1919, General Electric, which had been negotiating an agreement with Marconi relating to the use of GE's patented high-frequency Alexanderson alternator technology in Marconi's wireless stations,[247] agreed, at the suggestion of the United States Navy, to purchase a controlling interest in Marconi's American subsidiary and with it, the rights to the De Forest diode patent.[248] The result was the formation of the Radio Corporation of America ("RCA") and, soon thereafter, a sequence of cross-licensing arrangements among all major patent holders in the field.[249]

The standard account views the formation of RCA as a publicly-interested act of government intervention to save the market from patent deadlock.[250] It appears more accurate to say that the government intervened to pressure leading patent holders to enter into a different set of agreements to address that deadlock. To achieve its interests, the Navy enjoyed several sources of bargaining leverage: (1) it had acquired a large number of wireless stations;[251] (2) it had purchased

---

gress enacted legislation ordering the return of telephone and telegraph apparatuses to private ownership, effective March 1920. *See id.* at 116; Kruse, *supra* note 231, at 701.

243. *See* Brady, *supra* note 239, at 276; TYNE, *supra* note 222, at 171.

244. *See, e.g.*, AITKEN, *supra* note 215, at 249; Reich, *supra* note 213, at 216.

245. *See* Howells & Katznelson, Early Radio, *supra* note 16, at 14; S. G. STURMEY, THE ECONOMIC DEVELOPMENT OF RADIO 75 (1958).

246. *See* JAMES A. HIJIYA, LEE DE FOREST AND THE FATHERHOOD OF RADIO 94–95 (1992); MACLAURIN, *supra* note 215, at 85, 87; Reich, *supra* note 213, at 219**;** TYNE, *supra* note 222, at 126, 171–72. This agreement remained in force until July 1920, in connection with RCA's acquisition of AT&T's license to certain rights in the De Forest patent. *See id.* at 173 n.54.

247. *See* ARCHER, *supra* note 221, at 159. General Electric's Alexanderson alternator generated high-frequency alternating current for purposes of continuous wave radio transmission. *See* LEONARD S. REICH, THE MAKING OF AMERICAN INDUSTRIAL RESEARCH: SCIENCE AND BUSINESS AT GE AND BELL, 1876–1926, at 220–21 (1985).

248. *See* TYNE, *supra* note 222, at 307–08; ERIC P. WENAAS, RADIOLA: THE GOLDEN AGE OF RCA 22–23 (2007). One historian disputes that GE and Marconi were close to entering into a purchase agreement at the time the Navy intervened, although he does document intensive negotiations. *See* AITKEN, *supra* note 215, at 325–26.

249. *See* MACLAURIN, *supra* note 215, at 102–04; Howells & Katznelson, Early Radio, *supra* note 16, at 14–15.

250. *See* Merges, *Intellectual Property Rights and Bargaining Breakdown: The Case of Blocking Patents*, *supra* note 212, at 85.

251. *See* AITKEN, *supra* note 215, at 287.

critical radio patents;[252] (3) it had seized important radio-related patents from Telefunken, the leading German firm in the industry, under the Alien Enemy Property Custodian Act;[253] (4) it had developed internal production capacities during wartime;[254] and, as noted above, (5) it could use patented technologies without risk of injunctive relief.[255] Given this background, H&K characterize RCA's formation as a somewhat coercively imposed transactional arrangement that promoted the government's interests in securing domestic control over radio communications technology.[256] Alternatively, RCA's formation can be viewed as a voluntarily negotiated multi-lateral licensing arrangement among the Navy and other key patent holders, technology suppliers, and technology users. Each party — including the governmental buyer — sought to "expand the pie" by removing patent-related transactional obstacles to market exchange while using its bargaining power to secure the largest "slice" for itself.[257] Consistent with both interpretations, the Navy contributed patents to RCA, whose charter guaranteed a non-voting seat on the board for a representative of the United States military.[258]

RCA moved expeditiously to sweep aside transaction-cost obstacles to patent licensing in radio communications. In 1919, RCA entered into a patent cross-licensing agreement with GE. In 1920, RCA and AT&T, which held certain rights to De Forest's diode patent,[259] reached a ten-year royalty-free cross-licensing agreement, in connection with which AT&T purchased an interest in RCA.[260] That agree-

252. The acquisition blocked the sale of certain valuable patents to the British Marconi entity in 1918. *See* AITKEN, *supra* note 215, at 293–94.

253. The United States seized the "Meissner" patents relating to the use of a feedback circuit for generating oscillations. *See* MACLAURIN, *supra* note 215, at 97 n.29.

254. *See generally* HOWETH, *supra* note 227, at 208–211, 213–19, 223–65 (documenting Navy efforts to improve radio technology prior to and during World War I). In particular, the Navy had purchased patents to Poulsen arc transmitter technology, one of only three leading technologies at the time for continuous wave radio transmission (the others being GE's radio frequency alternator and De Forest's triode vacuum tube). *See* AITKEN, *supra* note 215, at 25.

255. *See supra* notes 237–239 and accompanying text.

256. *See* Howells & Katznelson, Early Radio, *supra* note 16, at 14.

257. There is some basis for believing that even GE's acquisition of Marconi's American subsidiary represented a voluntary market transaction that might have been reached even without government pressure. Despite Marconi's leading position in the market, it was vulnerable due to the imminent expiration of the Fleming diode patent in 1922, which would then allow AT&T to freely exploit the De Forest triode patent to which it held a license. Additionally, Marconi did not own any leading transmission technologies for continuous wave radio apparatuses, which had superseded Marconi's spark apparatus. This point is supported by the fact that, in Great Britain, where Marconi's diode patent had expired, Marconi voluntarily merged its valve operations with GE immediately prior to the formation of RCA. *See* W. J. BAKER, A HISTORY OF THE MARCONI COMPANY 178–89 (1970); STURMEY, *supra* note 245, at 35, 61.

258. *See* AITKEN, *supra* note 215, at 347.

259. *See supra* note 257 and accompanying text.

260. The two entities also agreed on certain market allocations: AT&T was given exclusive licenses in wired telegraphy and telephony and certain rights to radio in connection

ment removed any potential patent roadblock to exploiting both the Fleming patent held by Marconi and the De Forest patent (to which AT&T held a license) for purposes of long-distance radio transmission. In 1921, RCA entered into a cross-licensing agreement with Westinghouse, which in 1920 had acquired critical patents relating to electrical circuits.[261] These circuits were used in the radio receiver sets that would soon be marketed widely for home use with the advent of commercial radio broadcasting.[262] Within two years of the conclusion of World War I and six years of the district court decision favoring Marconi in 1916, any potential AC deadlock had largely been avoided. A single entity now controlled, or held licenses to, over 2000 patents relating to the fundamental technologies behind wire and wireless radio communications.[263] While some radio-related patent litigation continued[264] and the resulting aggregation of market power raised antitrust concerns,[265] the simple fact is that RCA represents a classic market-derived response to a potential but never-realized AC problem. While the government applied pressure that may have promoted a certain type of resolution, it appears that the parties had already reached another type of agreement without government intervention. Alternatively, that government intervention simply represented hard bargaining undertaken by the largest buyer in the market.

V. POLICY: DOES THE ANTI-COMMONS THESIS STILL MATTER?

The factual infirmities behind the positive component of the AC thesis imply infirmities in its normative component — namely, the view that patents and other IP rights should be significantly weakened in order to relieve the market from transaction-cost burdens and enable innovation to proceed more rapidly.[266] If realized AC effects are infrequent, then the proposed solution — retraction or relaxation of IP rights — appears to be moot. But that conclusion would be almost as

---

with the wire telephone network. They were also given an exclusive license in wireless telegraphy, international two-way radio communication and the manufacture of wireless telephone apparatus for amateur purposes. *See* MACLAURIN, *supra* note 215, at 105; DANIELIAN, *supra* note 221, at 111.

261. These patents related to the "Fessenden" heterodyne circuit and the "Armstrong" super-heterodyne (or "regenerative feedback") circuit. *See* ARCHER, *supra* note 221, at 168.

262. *See id.* at 168, 241.

263. *See, e.g.*, BAKER, *supra* note 257, at 180–81; MACLAURIN, *supra* note 215, at 107.

264. For a description of continuing litigation, see MACLAURIN, *supra* note 215, at 127–31.

265. The United States filed an antitrust suit against RCA in 1930. The suit resulted in GE and Westinghouse agreeing to divest their holdings in RCA and extension of the royalty-free cross-licensing agreements with GE and Westinghouse until 1954. *See* GLEASON L. ARCHER, BIG BUSINESS AND RADIO 353–86 (1939).

266. *See supra* note 4 and accompanying text.

crude an interpretation of the empirical evidence as the prevailing AC thesis. The observation that markets regularly mitigate or preclude AC effects through privately engineered pooling structures and other transactional arrangements strongly rebuts the AC thesis as a reliable description of IP-intensive technology and content markets. As a normative matter, however, qualifying the AC thesis in this way creates ambiguous implications as to the socially desirable strength of IP protection.

A. The Non-Excludable Counterfactual

If markets can correct for the transaction-cost deadlocks that may arise under strong forms of IP protection, then there seems little reason to reduce the force of IP rights, because doing so would raise the risk of discouraging investment in innovation. This argument is plausible but not fully persuasive. Even if markets can usually resolve or preempt IP thickets, it may be that a particular market would be better off if the state had never introduced IP rights or had made available weaker IP rights. Correcting for AC effects through contractual and other transactional structures is a costly process that consumes resources that could have been deployed elsewhere — for example, in the innovation activities that IP regimes are intended to promote. Thus, while a particular market may have a good solution to the AC problem, it might be even better off if it had never faced the problem in the first place.

This counterfactual question cannot be definitively resolved. Doing so requires identifying the alternative mechanisms that any particular market would have adopted in order to capture returns on innovation under some weaker level of IP protection, and then comparing the anticipated net social gains under that alternative regime against the net social gains under the stronger IP regime currently or historically in force in that market.[267] But even taking into account this non-excludable scenario, there is compelling ground to assert that the mere possibility of AC effects is not by itself a compelling basis for recommending significant retractions in IP protection. Historical experience in the aircraft, automotive, petroleum refining, and radio communications markets, as well as contemporary experience in the ICT and biopharmaceutical markets, show that even intensive levels

267. This fundamental and difficult question is not entirely intractable. Elsewhere I have argued that robust IP rights are the appropriate policy default given that the opportunity to adopt and enforce IP rights enables market participants to select from the complete feasible range of transactional structures for conducting and commercializing innovation. This in turn maximizes the likelihood that the market will select the cost-minimizing set of transactional structures, reducing innovation and commercialization costs and maximizing the net social gain. *See* Jonathan M. Barnett, *Intellectual Property as a Law of Organization*, 84 S. CAL. L. REV. 785, 816–17 (2011).

of patent issuance and enforcement do not yield persistent deadlocks resulting in significant delayed innovation or other adverse market outcomes. While there may be persuasive grounds for reducing the force of IP protections in particular markets, all evidence available to date indicates that AC effects are not one of them.

B. IP Pools and Knowledge-Sharing Gains

Thus far, I have discussed pooling and related arrangements as corrective actions that protect against depletions of social value by addressing potential or actual AC effects. But that view is incomplete. These arrangements may generate further social gains by enabling efficient exchanges of intellectual assets that would otherwise be economically irrational.

As has long been recognized, obstacles to contracting may prevent actual or potential competitors from engaging in transactions involving intellectual assets that must be disclosed in the course of negotiating the terms of any such transaction. Following the "information paradox," a third party's willingness to pay for an idea falls to zero upon disclosure since that party can then use the idea without paying the innovators. [268] Patents and other IP rights ameliorate this dilemma by enclosing intellectual assets in a property rights "envelope" that protects against unconsented use without agreed-upon terms of trade. The intricate contractual framework that supports the standard-setting and patent-licensing arrangements behind the ICT markets illustrates this proposition.[269] These complex arrangements put in place a common technological platform that has spawned competition in a rich set of complementary products and services markets. Without patents to protect firms' knowledge assets and to facilitate negotiation over the use of those assets, those firms might have declined to share or disclose the existence of those assets with actual or potential competitors. Such bargaining obstacles would slow the development and implementation of a common technology standard, which could in turn induce firms to develop proprietary standards that do not require technology-sharing with other firms.

To illustrate this point, consider the MPEG-2 patent pool. Tens of patent holders have contributed thousands of patents to a common pool, which the administrator has licensed at a uniform royalty rate to thousands of licensees, who have in turn manufactured and distributed products using the MPEG-2 audio-video compression standard.[270] The

---

268. *See* Kenneth Arrow, *Economic Welfare and the Allocation of Resources for Invention*, *in* THE RATE AND DIRECTION OF INVENTIVE ACTIVITY: ECONOMIC AND SOCIAL FACTORS 615 (1962).

269. *See supra* Part III.C.3.

270. For number of licensors and licensees in the MPEG-administered pools, see *supra* Table 2.

standard is critical for enabling video and audio data to be stored and transmitted efficiently, which in turn enables technologies such as DVD discs, Blu-Ray discs, online streaming, and certain functions in cable set-top boxes.[271] The availability of patents, and the pooling and cross-licensing arrangements that they have enabled, may have facilitated entry into ICT markets that would otherwise have been dominated by the holder of a single proprietary standard. In such cases, pooling arrangements not only reduce the social losses attributable to the transaction costs inherent to a strong IP system but also generate social gains through information-sharing transactions that would otherwise be infeasible.

C. IP Pools, Collusion Risk and Antitrust Treatment

Even if we accept the proposition that pooling arrangements generate social gains by mitigating AC effects and facilitating knowledge sharing, it is necessary to consider the risk that such arrangements may act as a mechanism for promoting collusive agreements among competitors. While this risk is inherent to any IP pooling arrangement, modern antitrust law has developed a set of tools with which regulators can mitigate collusion risk without taking the drastic step of dismantling pools.

1. Old and New Pools: Market and Enforcement Activity

There have been two waves of pooling activity in U.S. technology markets since 1900: (1) the period from the beginning of the 20th century until the late 1930s, with a spike toward the end of this period; and (2) the period from the late 1990s through the present.[272] As discussed previously[273] and indicated in Table 3 below, a wave of antitrust prosecutions during the 1940s and early 1950s, which typically resulted in modification or dissolution of the pool, suppressed the first wave of pooling activity. Of all documented pools formed between 1930 and 1938, ninety percent were contested in antitrust litigation and all of those contested pools were ultimately dissolved or modified.[274] Unsurprisingly, as shown previously in Figure 3, few documented pools were formed for the next several decades. As noted earlier, in the 1990s, regulatory actions by antitrust enforcement authorities signaled to the market that antitrust exposure associated with pooling activity had declined considerably.[275] The market response

271. For further discussion, see Barnett, *Patent Networks*, *supra* note 43, at 11.
272. *See supra* notes 82–82 and accompanying text; *see also supra* Figure 3.
273. *See supra* notes 82–82 and accompanying text.
274. *See infra* Table 3.
275. *See supra* notes 82–82 and accompanying text.

was dramatic. As shown in Table 3 below, documented pools have proliferated, few have been contested on antitrust grounds, and none have been dissolved or modified.

Based on Table 3 below, currently formed patent pools might appear to face virtually no risk of prosecution or other antitrust litigation, implying that antitrust agencies effectively treat pooling arrangements as per se legal. That impression is misleading. The low rate of litigation and zero rate of modification and dissolution during the modern period understates the significant influence of antitrust constraints.[276] This is because firms only rationally enter into pooling arrangements that are structured in reasonable compliance with the applicable guidelines set forth by the enforcement agencies.[277] Additionally, as shown below, pool administrators sometimes have procured de facto "pre-approvals" through the "business review letter" procedure.[278] These policy signals have influenced the design of patent pools, which now typically include precautionary mechanisms that were often lacking in the first period of patent pooling.

276. It should be noted that the high rate of litigation, modification and dissolution with respect to documented pools in the first half of the 20th century may overstate to some extent the liability exposure of IP pooling arrangements during that period. Since I generally identified pools established during that period through litigation databases, there may have been other pools in existence that were not documented through the sources I accessed and were not litigated, modified or dissolved. Nonetheless, given the dramatic difference in enforcement trends between the two periods, it is unlikely that any such overstatement would alter the underlying difference in kind between the enforcement policies toward patent pools pursued in each of the two periods.

277. *See generally* DEP'T OF JUST. & FED. TRADE COMM'N, *supra* note 152. For further discussion, see HERBERT HOVENKAMP, MARK LEMLEY & MARK JANIS, INTELLECTUAL PROPERTY AND ANTITRUST: AN ANALYSIS OF ANTITRUST PRINCIPLES APPLIED TO INTELLECTUAL PROPERTY LAW § 34.4a2 (2009).

278. The business review letter process is a statutory procedure by which parties to a proposed transaction can request an indication from the Antitrust Division of the Department of Justice as to whether the Department currently intends to take action on antitrust grounds against the transaction if consummated. The most positive indication is that the Department currently has no intention to take action on antitrust grounds against the proposed transaction if consummated. For further details on the business review letter procedure, see 28 C.F.R. § 50.6 (2010).

Table 3: Antitrust Treatment of Documented Pooling Arrangements (1900–July 2015)[279]

Period (Pool For-For-mation)	Number of Pools Formed	% Managed by External Administra-tor	% Con-tested (on Antitrust Grounds)	% Ter-minated or Mod-ified	% Received Business Review Letter
1900–1945	55	5.5%	87%	80%	n/a
1933–1938 (New Deal)	21	0%	90%	90%	n/a
1946–1994	10	10%	60%	50%	10%
1995–July 2015	40	95%	10%	0%	18%
Total	105	33%	46%	38%	6%

2. Assessing Collusion Risk

Modern antitrust analysis agrees that a blanket anti-pooling or pro-pooling policy is incompatible with the ambiguous welfare effects of pooling arrangements. As discussed above, pools generate two social gains: (1) they preempt deadlocks that may arise as a result of conflicting IP claims and (2) they enable knowledge-sharing resulting in broader dissemination of IP-protected assets. However, as antitrust agencies argued in the late New Deal and for decades thereafter, pools inherently carry collusive risk insofar as members may use the pool mechanism to implement disguised price-fixing arrangements. But New Deal and postwar antitrust policy failed to identify more precisely the circumstances in which an IP pool can plausibly give rise to collusion risk. Collusion risk in the IP-pooling context only plausibly arises with respect to substitute patents, which cover technologies that do not stand in a blocking or complementary relationship. If two or more patented technologies are substitutes (for example, each technology achieves a particular objective in a different but equally effective way), then pooling those patents suppresses efficiency gains from market competition that would otherwise take place. If two or more patents do not stand in a blocking or complementary relationship, then formation of the pool does not generate efficiency gains, either by enabling subsequent innovation to proceed without impediment or by

279. All antitrust litigations were located through the Westlaw, LexisNexis, and Intelli-Connect (CCH) litigation databases and the ProQuest historical newspapers database. For this purpose, "Contested" refers to any pool that was subject to documented antitrust litigation brought by a government agency or private entity. I do not consider a pool to have been contested if it received a favorable business review letter or if the pool initiated litigation against an alleged infringer. Note that "Managed by External Administrator" refers to any pool that is managed by a third-party administrative entity or any consortium that is managed by a functionally independent administrative entity. For the definition of pool as used in compiling this Table, see *supra* note 17 and accompanying text.

enabling the efficient bundling of complementary products and services.[280] Where either of these two conditions is not satisfied, pool formation yields efficiency gains. For example, a pool consisting of blocking patents held by a pioneer and improver yields efficiency gains because the pool preempts deadlock. Similarly, a pool consisting of complementary patents held by two unrelated parties that stand in an actual or potential competitive relationship generates knowledge-sharing synergies. In short: some pools are good, some are bad, and some are a mixture of both.

This analysis is complicated by an additional scenario. Some pooling arrangements may be a means by which firms collude to reduce the price of IP-protected assets below the price that would prevail in arm's-length market negotiation. While this results in an immediate price reduction for users of those IP assets and end-products that embody those assets, it may result in long-term social harm to the extent it prevents IP producers from earning a sufficient return to cover R&D and other fixed costs. This is a plausible scenario when buyers or licensees of the relevant technological or creative input can collectively exert sufficient bargaining power to compel suppliers or licensors to reduce the price of those inputs below efficient levels. This is particularly relevant to R&D-intensive entities in technology markets or content holders in creative markets.[281] The efficient long-term price must reflect both short-term variable costs and long-term fixed costs. In the case of informational assets, the variable costs are often nominal while the fixed costs are significant. For example, the short-term variable cost to deliver an additional download of a software program is close to zero while the long-term fixed cost includes the significant expenditures required to develop that program. Hence, setting price equal to variable cost imposes long-term efficiency losses by preventing upstream suppliers of technological and creative inputs from recovering the fixed costs of invention or creation. As discussed above, H&K argue that a monopsonistic motive on the part of the military may have driven formation of pooling arrangements in the aviation market[282] and the wireless communications market.[283] As I have argued elsewhere, monopsonistic motives may account in part for the formation and design of some patent pools currently in opera-

280. *See, e.g.*, WARD BOWMAN, PATENTS AND ANTITRUST 200–02 (1973); Lerner et al., *supra* note 67; Mark Janis, *Aggregation and Dissemination Issues in Patent Pools*, *in* ISSUES IN COMPETITION L. AND POL'Y 111 (2005); *cf.* HOVENKAMP ET AL., *supra* note 277, at §§ 34.2, 34.4.

281. Other authors have observed that pools can operate as monopsonies that artificially depress the price of the licensed technology. *See* HOVENKAMP ET AL., *supra* note 277, at § 35.6b; J. Gregory Sidak, *Patent Holdup and Oligopsonistic Collusion in Standard-Setting Organizations*, 5 J. COMPETITION L. & ECON. 123, 143–46, 149–51 (2009).

282. *See supra* Part IV.A.1.b.

283. *See supra* Part IV.B.4.

tion in ICT markets.[284] In this case, there is no longer any assurance that the formation of a patent pool results in a net long-term social welfare gain, even if the short-term result reduces transaction costs or generates lower prices for consumers.

3. The Modern Regulatory Approach

Modern antitrust law is sensitive to the constrained levels of collusion risk inherent to pooling and similar arrangements and has supplied regulators with a sensitive set of tools by which to surgically limit that risk without requiring dissolution of an existing pool. That measured approach is reflected in the IP-related guidelines that have governed antitrust enforcement since the mid-1990s.[285] It is also exemplified by the structural templates that antitrust agencies have provided to the market since the late 1990s in the form of business review letters, in which the antitrust agency expresses its prosecution intentions with respect to a proposed transaction and, implicitly, with respect to other transactions that follow a similar structure.[286] As shown in Table 3 above, the influence of these regulatory signals is evident in the key distinguishing characteristic of modern pools: 95% of pools formed after 1994 are managed by an external administrative entity, as compared to only 6% of all pools formed prior to that year.[287] Administration by a third-party entity significantly reduces collusion risk, due to the arm's-length relationship between the administrator and the pool member, the administrator's repeat-play incentives to

284. Detailed analysis of ICT patent pools, which are dominated by large integrated hardware manufacturers, suggests that these pools are established not only to reduce or preempt AC effects but to reduce the price that must be paid to upstream providers of R&D inputs by electronics and communications equipment manufacturers. *See* Barnett, *Patent Networks*, *supra* note 43, at 35.

285. *See generally* DEP'T OF JUST. & FED. TRADE COMM'N, *supra* note 277.

286. For discussion of the business review letter procedure, see *supra* note 278 and accompanying text. *See also* Letter from Thomas O. Barnett, Acting Assistant Att'y Gen., Antitrust Div., Dep't of Just., to William F. Dolan & Geoffrey Oliver (Oct. 21, 2008), http://www.justice.gov/atr/public/busreview/238429.pdf [http://perma.cc/3ZYT-E29U]; Letter from Thomas O. Barnett, Acting Assistant Att'y Gen., Antitrust Div., Dep't of Just., to Michael A. Lindsay, Esq. (Apr. 30, 2007), http://www.justice.gov/atr/public/busreview/222978.pdf [http://perma.cc/B8WY-5U34]; Letter from Charles A. James, Assistant Att'y Gen., Antitrust Div., Dep't of Justice, to Ky P. Ewing, Esq. (Nov. 12, 2002), http://www.usdoj.gov/atr/public/busreview/200455.pdf [http://perma.cc/9TBA-AQPK]; Letter from Joel I. Klein, Acting Assistant Att'y Gen., Antitrust Div., Dep't of Just., to Garrard R. Beeney, Esq. (Dec. 16, 1998), http://www.justice.gov/sites/default/files/atr/legacy/2006/04/27/2121.pdf [http://perma.cc/YL53-VKK8]; Letter from Joel I. Klein to Gerrard R. Beeney, *supra* note 80.

287. For purposes of calculating this percentage, I deem a pool to be managed "externally" if it is managed by an entity that is meaningfully independent of the pool members-licensors. This approach yields a clear dividing line for most pools. However, the DVD 3C and DVD 6C consortia are borderline cases. Hence, they are designated as a mixed contractual/administrative arrangement in this Article. For purposes of this calculation, I treat those consortia as internally administered arrangements.

maintain a reputation for fair dealing among the licensee population, or both.

In addition to external administration, current patent pools generally conform to a set of de facto requirements that are designed to limit collusion opportunities. These requirements include:

(i) the pool must encompass only complementary, and not substitute, patents;
(ii) the pool must license its portfolio to all parties on RAND terms;
(iii) the pool must make membership available only to licensors with patents deemed "essential" to the relevant standard;
(iv) the pool must permit each member-licensor to license its patents independently (that is, the license to the pool is always non-exclusive); and
(v) the pool must not impose any direct or indirect restraints on each licensor's or licensee's pricing and output decisions.[288]

As I have documented elsewhere, the pools managed by the MPEG-LA entity, currently the leading pool administrator in the ICT market, apparently conform to these requirements insofar as all ICT pools administered by MPEG-LA provide non-exclusive licenses on a RAND basis.[289] These pools provide additional protection to licensees in some cases in the form of royalty caps and, in all cases, rate protection at renewal times and grant-back clauses.[290] Compliance with these implicit requirements, as well as the use by some pools of the pre-emptive business review letter procedure, most likely accounts for the low rates of antitrust litigation and the zero rate of antitrust prosecution, pool modification, and pool dissolution observed since the renewal of patent pooling in the late 1990s.[291] This regulatory policy appears to have achieved a nuanced outcome that protects the efficiency gains available through cooperative standard setting and li-

288. For a full review, see DEP'T OF JUST. & FED. TRADE COMM'N, ANTITRUST ENFORCEMENT AND INTELLECTUAL PROPERTY RIGHTS: PROMOTING INNOVATION AND COMPETITION 77–78 (Apr. 2007). For further discussion, see HOVENKAMP ET AL., *supra* note 277, at § 34.4.

289. *See* Barnett, *Patent Networks*, *supra* note 43, at 52.

290. *See id.* at 38–39. Grant-back clauses protect licensees against hold-up risk by requiring licensors and licensees to make available to all licensees on RAND terms any patents that (1) any such licensor or licensee is later granted or later acquires and (2) are "essential" to the relevant standard technology.

291. Note that discussions of contemporary patent pools sometimes refer to an FTC enforcement action that resulted in the dissolution of a patent pool involving two firms in the market for equipment and technology used in corrective eye surgery. *See* Press Release, Fed. Trade Comm'n, Summit and VISX Settle FTC Charges of Violating Antitrust Laws (Aug. 21, 1998). I do not include this arrangement in my discussion because it only involved two firms and therefore does not meet the definition of a pool as used in this paper.

censing arrangements while minimizing the attendant risk of collusive effects on pricing and output.

VI. CONCLUSION

IP scholars and policymakers often maintain that AC effects are endemic in IP-governed markets and therefore tend to endorse the view that IP rights should be reduced to mitigate those effects. The descriptive component of that proposition cannot be reconciled with the clear weight of contemporary and historical evidence — covering more than a century's worth of experience — that AC effects are repeatedly mitigated through independent market action by affected constituencies or transactional entrepreneurs. This is true both in concentrated markets, in which repeat players have incentives and capacities to converge on a knowledge-sharing arrangement, and dispersed markets, in which intermediaries commonly supply transactional solutions that ameliorate AC frictions. Remarkably, this proposition holds even in historical cases that have long been assumed to provide clear illustrations of AC effects. Recognizing the shortcomings of the AC thesis as a descriptive proposition rebuts normative intuitions that intensive levels of IP acquisition and enforcement trap markets in a transaction-cost web that depresses innovation. This sophisticated view of AC effects as a potential but rarely realized outcome provides the basis for a more nuanced appreciation of the role of IP rights in creative and technology markets.

VII. APPENDIX: DOCUMENTED IP POOLING ARRANGEMENTS (1900–JULY 2015)[292]

292. The below list is restricted to documented pooling arrangements that (1) involve three or more holders of patents or copyrights; (2) were established between 1900 and July 14, 2015; and (3) have some connection to the U.S. market. The list was compiled based on the following steps and omits arrangements that were not documented or could not be confirmed through the sources mentioned below. First, I used an existing list of patent pools in information, communications, and technology markets formed since 1995, which I had prepared and confirmed for a companion publication. *See generally* Barnett, *Patent Networks*, *supra* note 43. For purposes of this Table, I have updated all information with respect to those pools as of July 14, 2015, based on information disclosed on the pool administrator or consortium's website. Second, I compiled references to pre-1995 pools found in existing contributions, including especially Lerner et al., *supra* note 67, and VAUGHAN, *supra* note 120; Merges, *Contracting Into Liability Rules*, *supra* note 5; Ryan L. Lampe & Petra Moser, *Do Patent Pools Encourage Innovation? Evidence from 20 U.S. Industries Under the New Deal* (Nat'l Bureau of Econ. Research, Working Paper No. 18316, 2012); Richard J. Gilbert, *Antitrust for Patent Pools: A Century of Policy Evolution*, 2004 STAN. TECH. L. REV. 3. Third, I confirmed the existence of those pools (and conformity to the definition set forth above), identified additional pools, and obtained information on certain pool characteristics through the following sources: (1) the Westlaw, LexisNexis, and IntelliConnect (CCH) databases of federal judicial decisions and consent decrees; (2) TEMP. NAT'L ECON. COMM'N, 77TH CONG., INVESTIGATION OF CONCENTRATION OF ECONOMIC POWER: FINAL REPORT OF THE EXECUTIVE SECRETARY (1941); (3) *Pooling of Patents: Hearings on H.R. 4523 Before the H. Comm. on Patents*, 74th Cong. (1935); (4) *Patents: Hearings on S. 2303 and S. 2491 Before the S. Comm. on Patents*, 77th Cong. (1942); and (v) the ProQuest historical newspapers database. Except as indicated below, whenever I include a citation to a judicial decision, all information for the relevant pool is based on that decision. In all other cases, information is based on other indicated sources.

Year Est.[293]	Market	No. of IP Holders-Members[294]	Arrangement[295]	Antitrust Outcome[296]
1900	Harvesting technology	8	Corp	Upheld (1903)[297]
1907	Bicycle and motorcycle coaster brakes	9	Corp, Contract	Terminated (1913)[298]
1907	Explosives; ammunition; other chemical products	9[299]	Contract	Terminated (1952)[300]
1908	Film projector equip-	4[301]	Corp	Terminated

293. If a pool arrangement is based on multiple agreements, the "Year Est." refers to the year in which the earliest such agreement was executed.

294. This refers to the number of entities contributing patents (or, in some cases, copyrights) to the pool. If two entities stand in a parent-subsidiary relationship, I treat those two entities as a single entity. For post-1995 pools, this number is based on information disclosed on the website of the pool's administrator or consortium. For pre-1995 pools, this number is usually based on information set forth in the accompanying litigation (as indicated in the last column). If that information was not disclosed in the litigation, I relied on information set forth in other sources as indicated. In a small number of pre-1995 pools, it was not possible to determine definitively which named pool members had contributed patents, in which case I assumed that all members had contributed patents.

295. There are four possible arrangements: (1) a cross-licensing agreement among the patent holders, designated as "Contract;" (2) a trade association that administers the patents contributed to the pool by its members, designated as "Assoc.;" (3) formation of a new for-profit entity that owns and administers the members' patents, designated as "Corp.;" and (4) an independent third-party administrator that manages the pool on behalf of the members, designated as "Admin."

296. This column captures litigations that contested some features of the pool on antitrust grounds. This is based on litigations for which published decisions or other orders are found in the Westlaw, LexisNexis, or IntelliConnect (CCH) databases and therefore ignores litigations that were commenced but not litigated through judgment or a consent decree. "Terminated" means that the pool arrangement or underlying set of contracts was formally enjoined. "Modified" means that the licensing arrangement was permitted to persist in some form subject to certain modifications. "Not contested" means that there was no record in litigation or trade press databases that a government or private plaintiff had initiated an antitrust cause of action against the pool. "Reviewed via business review letter" denotes favorable review by an antitrust agency pursuant to the "Business Review Letter" procedure, in connection with which the agency indicated no current intention to prosecute.

297. U.S. Consol. Seeded Raisin Co. v. Griffin & Skelley Co., 126 F. 364, 369–72 (9th Cir. 1903).

298. United States v. New Departure Mfg. Co., 204 F. 107, 115 (W.D.N.Y. 1913).

299. This refers to the number of corporate co-conspirators identified in the related antitrust litigation, which involved complex global market-division arrangements between the DuPont and ICI (previously Nobel) corporate groups. While the litigation focused on cross-licensing agreements involving the DuPont and ICI groups, it also identified third parties or partially controlled entities that were party to some of those agreements. I have therefore treated these relationships as a "pooling" arrangement for purposes of this list. *See* United States v. Imperial Chem. Indus., Ltd., 100 F. Supp. 504, 508–09 (S.D.N.Y. 1951).

300. *See id.* at 592 (ordering compulsory licensing of pooled patents at reasonable royalty and divestiture of holdings in certain jointly-owned entities).

Year Est.[293]	Market	No. of IP Holders-Members[294]	Arrangement[295]	Antitrust Outcome[296]
	ment			(1915)[302]
N/A	Liquid door check (lock)	4	Contract	Terminated (1909)[303]
1910	Bathtub enameling tools	3	Assoc	Terminated (1912)[304]
1914	Automobiles	136[305]	Assoc	Not contested (expired 1957)[306]
1914	Music performance rights	Approx. 500,000[307]	Admin	Modified (1941)[308]
1914	Rear axle structures[309]	3	Corp	Not contested
1916	Folding beds[310]	4	Corp	Not contested[311]
1916	Railroad car couplers	4	Assoc	Upheld (1957)[312]
1916	Glassware manufacturing machinery	5	Contract; Corp	Modified (1945)[313]

301. As of the time of the accompanying antitrust litigation, it appears there were eleven members of the pool. *See* United States v. Motion Picture Patents Co., 225 F. 800, 801 (E.D. Pa. 1915). However, based on a historical account, four entities contributed patents to the Motion Picture Patents Company at its founding. *See* CHARLES MUSSER, BEFORE THE NICKELODEON: EDWIN S. PORTER AND THE EDISON MANUFACTURING COMPANY 438 (1991).

302. *See Motion Picture Patents Co.*, 225 F. at 801.

303. *See* Blount Mfg. Co. v. Yale and Towne Mfg. Co., 166 F. 555, 562 (D. Mass. 1909).

304. Standard Sanitary Mfg. v. United States, 226 U.S. 20, 21 (1912).

305. Number of members at founding of the association. *See supra* note 116.

306. *See* WHITE, *supra* note 120, at 213.

307. *See* Press Release, Am. Soc'y of Composers, Authors and Publishers, ASCAP Celebrates 100th Birthday with Top Songs Lists; NYC and Tennessee Proclaim February 13th "ASCAP Day" (Feb. 13, 2014), http://www.ascap.com/press/2014/0213-ascap-turns-100 [http://perma.cc/PHR4-9GZM].

308. Since 1941, ASCAP's rates and other policies have been subject to judicial review by consent decree, and have been modified. *See, e.g.*, United States v. Am. Soc'y of Composers, Authors and Publishers, 1940-43 Trade Cas. (CCH) ¶ 56,104 (S.D.N.Y. 1941); United States v. Am. Soc'y of Composers, Authors and Publishers, 1950–51 Trade Cas. (CCH) ¶ 63,751 (S.D.N.Y. 1950); United States v. Am. Soc'y of Composers, Authors and Publishers, 559 F. Supp. 2d 332, 415 (S.D.N.Y. 2008).

309. *See* Rae, *supra* note 91, at 85 n.60.

310. Kramer v. Comm'r, 27 B.T.A. 1043, 1045 (1933).

311. The case was litigated on tax-related issues. *See generally id.*

312. United States v. Nat'l Malleable & Steel Castings Co., 1957 Trade Cas. (CCH) ¶ 73,604 (N.D. Ohio 1957).

313. Hartford-Empire Co. v. United States, 46 F. Supp. 541, 622 (N.D. Ohio 1942), *modified*, 323 U.S. 386, 435 (1945), *clarified* 324 U.S. 570, 571 (1945).

Year Est.[293]	**Market**	**No. of IP Holders-Members**[294]	**Arrangement**[295]	**Antitrust Outcome**[296]
1917	Automobile bumpers	11	Assoc	Terminated (1917)[314]
1917	Aircraft	25[315]	Assoc	Terminated (1975)[316]
1919	Radio	5[317]	Contract; Corp	Modified (1932)[318]
1920	Titanium (pigment)	22	Contract	Terminated (1945)[319]
1921	Cracking process for refining petroleum	4	Contract	Upheld (1931)[320]
1925	Prismatic glassware	3	Contract	Terminated (1954)[321]
1926	Peach-pitting machines	4	Corp	Terminated (1954)[322]
1926–28	Sound reproduction technology[323]	4	Contract	Not contested[324]

314. United States v. Discher, 235 F. 719, 719 (S.D.N.Y. 1919).

315. *War and Peace and the Patent System*, FORTUNE, Aug. 1942, at 105.

316. United States v. Mfrs.' Aircraft Ass'n, 1976-1 Trade Cas. (CHH) ¶ 60,810 (S.D.N.Y. 1975).

317. *See supra* notes 249–251 and accompanying text.

318. United States v. Radio Corp. of Am., 1932–1939 Trade Cas. (CHH) ¶ 55,015 (D. Del. 1932) (approving consent decree that ordered General Electric and Westinghouse to dispose of equity interests in RCA and modifying cross-licensing agreements to delete exclusivity and territorial division provisions).

319. United States v. Nat'l Lead Co., 63 F. Supp. 513 (1945), *aff'd*, 332 U.S. 319 (1947).

320. Standard Oil Co. v. United States, 33 F.2d 617 (D.C. Ill. 1929), *rev'd*, 283 U.S. 163 (1931). The litigation attacked multiple pools, as follows. In 1921, the Texas and Indiana oil companies had pooled their patents; in 1923, the Gasoline Products Company and Texas companies had pooled their patents and, separately, the Indiana, Texas and New Jersey companies had pooled their patents. *See id.* at 167–68.

321. United States v. Holophane Co., 119 F. Supp. 114 (S.D. Ohio 1954).

322. United States v. Food Mach. & Chem. Corp., 1954 Trade Cas. (CHH) ¶ 67,829 (N.D. Cal. 1954); *"Patent Pool" Cited in Anti-Trust Suit*, N.Y. TIMES, Nov. 22, 1949, at 50.

323. In 1926, patent cross-licensing agreements were entered into involving Western Electric, an AT&T subsidiary that had developed a sound reproduction technology for use in motion pictures, Vitaphone (a subsidiary of the Warner Brothers studio), and the Fox-Case entity, which had developed a competing sound technology. In 1928, the agreements were superseded by licensing agreements involving Electrical Research Products, an AT&T affiliate formed to license the sound technology, and all major studios. *See* DOUGLAS GOMERY, THE COMING OF SOUND: A HISTORY 37–38, 42, 50, 71–75 (2005). For related agreements, see *Pooling of Patents: App. to Hearings on H.R. 4523 Before the H. Comm. on Patents*, 74th Cong. 1241–339 (1935) (Exhibit Nos. 9-11E). I am ignoring pooling arrangements that were entered into between Western Electric, RCA and certain German patent holders with respect to non-U.S. markets. *See* GOMERY, *supra*, at 109–11.

324. Antitrust suits do not appear to have been brought directly against the cross-licensing arrangements. In 1932, Warner Brothers and other firms sued AT&T and its affili-

Year Est.[293]	Market	No. of IP Holders-Members[294]	Arrangement[295]	Antitrust Outcome[296]
1927	Lamps and lamp-making machinery	9[325]	Contract	Terminated (1953)[326]
1927	"Mechanical license" for use of musical composition in sound recording	>46,000[327]	Admin	Not contested
1927	Air conditioning equipment[328]	6	Corp	Terminated (1945)[329]
1927	Plastics and acrylic products	4	Contract	Terminated (1948)[330]
1928	Rail joint bars	3	Contract	Terminated (1946)[331]
1929	Flat glass	9	Contract	Terminated (1948)[332]

ates on antitrust grounds with respect to the terms of the agreements under which the AT&T affiliates leased equipment for the theatrical exhibition of motion pictures. For related documents, see *Pooling of Patents: App. to Hearings on H.R. 4523 Before the H. Comm. on Patents*, 74th Cong. 1340–78 (1935) (Exhibit Nos. 11F–11I). The suits apparently settled in 1934 and the parties entered into modified licensing agreements. *See id.* at 1372–410 (Exhibit Nos. 11H–11K).

325. This number refers to General Electric, Westinghouse, Corning, Philips and "B" licensees who were party to agreements in which GE acted as licensor, subject to a reciprocal license in favor of GE. *See* United States v. Gen. Elec. Co., 82 F. Supp. 753, 874–75 (D.N.J. 1949).

326. United States v. Gen. Elec. Co., 115 F. Supp. 835 (D.N.J. 1953) (terminating certain agreements between defendants, dedicating to the public certain patents and requiring that GE license certain patents at a zero or reasonable royalty to all applicants). For related consent decrees involving lamp patents owned or controlled by Westinghouse, see United States v. Gen. Elec. Co., 1954 Trade Cas. (CHH) ¶ 67,794 (D.N.J. 1954), and for lamp patents owned or controlled by Corning, see United States v. Gen. Elec. Co., 1946–1947 Trade Cas. (CHH) ¶ 57,448 (D.N.J. 1946).

327. *See* Peter DiCola & David Touve, *Licensing in the Shadow of Copyright*, 17 STAN. TECH. L. REV. 397, 447 (2014); Press Release, Harry Fox Agency, HFA's Slingshot Provides Rights Management Support to Mobile Music App, Hook'd (July 28, 2014), https://www.harryfox.com/documents/press_releases/MuseAmi.pdf [https://perma.cc/VBH9-K9BK].

328. United States v. Auditorium Conditioning Corp., 52 F. Supp. 528 (S.D.N.Y. 1943).

329. United States v. Auditorium Conditioning Corp., 1944–1945 Trade Cas. (CHH) ¶ 57,428 (S.D.N.Y. 1945).

330. United States v. Rohm & Haas Co., 1948–1949 Trade Cas. (CHH) ¶ 62,334 (E.D. Penn. 1948) (terminating agreements and requiring defendant to offer zero-royalty license to all applicants). For some of the underlying agreements, see *Patents: Hearings on S. 2303 and S. 2491 Before the S. Comm. on Patents*, 77th Cong. 748–55, 759–60, 763–66 (1942) (Hutchinson Exhibit Nos. 1, 2, 6, 8).

331. United States v. Rail Joint Co., 1946–1947 Trade Cas. (CCH) ¶ 57,469 (N.D. Ill. 1946).

332. United States v. Libbey-Owens-Ford Glass Co., 1948–1949 Trade Cas. (CCH) ¶ 62,323 (N.D. Ohio 1948).

Year Est.[293]	Market	No. of IP Holders-Members[294]	Arrangement[295]	Antitrust Outcome[296]
1929	Coated abrasives	9	Contract; Corp	Terminated (1950)[333]
1930	Petroleum refining (hydrogenation processes)	4	Corp[334]	Terminated (1942)[335]
1931	Machine tools	6	Contract	Terminated (1954)[336]
1932	Loud speakers	4	Contract	Unknown[337]
1932	Radio receivers for color television[338]	6	Contract	Modified (1958)[339]
1933	Machine tools	6	Contract; Corp	Terminated (1955)[340]
1933	Hydraulic oil pumps	2	Contract; Corp	Terminated (1952)[341]
1933	Petroleum refining (Gray Processes Co.)	5	Contract; Corp[342]	Not contested
1933	Petroleum refining (Jersey Union Indiana & Kellogg Group)	4	Contract[343]	Terminated (1942)[344]
1933	Fluid-filled cable	4	Contract	Terminated

333. United States v. Minn. Mining & Mfg., Co., 92 F. Supp. 947, 964 (D. Mass. 1950).

334. *Hydrogenation Process Shared: Major Oil Refiners Hold Participation in New Hydro Patents Company*, WALL ST. J., July 14, 1930, at 12; *Documents and Agreements Defining and Relating to the Mutual Licensing Plan of Hydro Patents Co. for the Hydrogenation Process, as amended July 1, 1935 in Pooling of Patents: App. to Hearings on H.R. 4523 Before the H. Comm. on Patents*, 74th Cong. 3776–812 (1935).

335. United States v. Standard Oil Co., 1940–1943 Trade Cas. (CCH) ¶ 56,198 (D.N.J. 1942) (ordering by consent decree compulsory licensing of defendants' patents at zero royalty during the war and with reasonable royalties thereafter).

336. United States v. Cincinnati Milling Mach. Co., 1954 Trade Cas. ¶ 67,733 (E.D. Mich. 1954).

337. Lynch v. Magnavox Co., 94 F.2d 883 (9th Cir. 1938) (reversing the district court's dismissal of the antitrust claim on summary judgment). There is no available information concerning the final outcome of the litigation.

338. Zenith Radio Corp. v. Radio Corp. of Am., 106 F. Supp. 561 (D. Del. 1952).

339. Edward Ranzal, *R.C.A. Yields in Trust Suit; Will Ease Patent Licensing*, N.Y. TIMES, Oct. 29, 1958, at 1; *RCA to Open Up 10,000 Radio, TV Patents as It Settles Antitrust Suit*, WALL ST. J., Oct. 29, 1958, at 3.

340. United States v. Associated Patents, Inc., 134 F. Supp. 74 (E.D. Mich. 1955).

341. Kobe, Inc. v. Dempsey Pump Co., 198 F.2d 416 (10th Cir. 1952).

342. *Purchase and Cross-License Agreement (1933) in Pooling of Patents: App. to Hearings on H.R. 4523 Before the H. Comm. on Patents*, 74th Cong. 3733–75 (1935).

343. *An Agreement re "H.C. Technique" (Oct. 27, 1933) in Pooling of Patents: App. to Hearings on H.R. 4523 Before the H. Comm. on Patents*, 74th Cong. 3704–17 (1935).

344. United States v. Standard Oil Co., 1940–1943 Trade Cas. (CCH) ¶ 56,198 (D.N.J. 1942) (ordering by consent decree compulsory licensing of defendants' patents at zero royalty during the war and with reasonable royalties thereafter).

Year Est.[293]	Market	No. of IP Holders-Members[294]	Arrangement[295]	Antitrust Outcome[296]
				(1948)[345]
1934	Magnesium	4	Contract; Corp[346]	Terminated (1942)[347]
1934	Lecithin	4	Contract; Corp	Terminated (1947)[348]
1934	Variable condensers (radio tuning device)	4	Contract; Corp	Terminated (1953)[349]
1934	Petroleum refining (fractional distillation)	3	Corp[350]	Not contested
1934	Dry ice technology	3	Corp	Terminated (1954)[351]
1935	Aircraft instruments	13	Contract	Terminated (1946)[352]
1935	Dyestuffs	8	Contract[353]	Terminated (1952)[354]
1935	Silk hosiery production	7	Contract[355]	Terminated (pa-

345. United States v. Gen. Cable Corp., 1948–1949 Trade Cas. (CCH) ¶ 62,300 (S.D.N.Y. 1948).

346. *Hearings on S. 2303 and S. 2491 Before the S. Comm. on Patents*, 77th Cong. 1087–91 (1942) (Arnold Exhibit No. 32).

347. United States v. Aluminum Co. of Am., 1940–1943 Trade Cas. (CCH) ¶ 56,200 (S.D.N.Y. 1942) (terminating by consent decree agreements relating to the production of magnesium, making production patents royalty-free during the war and subject to reasonable royalties thereafter and making fabrication patents royalty-free).

348. United States v. Am. Lecithin Co., 1946–1947 Trade Cas. (CCH) ¶ 57,542 (N.D. Ohio 1947).

349. United States v. Gen. Instrument Corp., 87 F. Supp. 157 (D.N.J. 1949), *aff'd*, 115 F. Supp. 582 (D.N.J. 1953).

350. *License Agreement re Fractional Distillation (May 28, 1934) in Pooling of Patents: App. to Hearings on H.R. 4523 Before the H. Comm. on Patents*, 74th Cong. 3698–701 (1935).

351. United States v. Liquid Carbonic Corp., 1952–1953 Trade Cas. (CCH) ¶ 67,248 (E.D.N.Y. 1954).

352. United States v. Bendix Aviation Corp., 1946–1947 Trade Cas. (CCH) ¶ 57,444 (D.N.J. 1946).

353. *Hearings on S. 2303 and S. 2491 Before the S. Comm. on Patents*, 77th Cong. 2537–58 (1942) (Pack Exhibit Nos. 141–150).

354. Criminal antitrust prosecutions were initiated against the members of this pool in 1941. *See id* at 2589–619. It appears that the pool was dissolved, given that the U.S. government seized two members of the cartel during World War II. *See Halbach Cleared in Dye Trust Case: Federal Jury Deliberates 10 Hours on Charges of Plot to Form World Cartel*, N.Y. TIMES, Jan. 26, 1952, at 6.

355. Multiple applicants for a patent on a single invention agreed to settle their priority dispute through arbitration, with the intention of forming a "patent pool." *See* Julius Kayser & Co. v. Rosedale Knitting Co., 18 F. Supp. 836, 837 (E.D. Pa. 1937), *aff'd*, 98 F.2d 839 (3d Cir. 1938).

Year Est.[293]	Market	No. of IP Holders-Members[294]	Arrangement[295]	Antitrust Outcome[296]
	technology			tent invalidated) (1937)[356]
1935	Petroleum refining (gas polymerization)	5	Contract[357]	Terminated (1942)[358]
1935	Flat glass	9	Contract	Terminated (1948)[359]
1937	Parking meters	7	Contract; Corp	Terminated (1944)[360]
1937	Metal wheels	3	Contract	Terminated (1955)[361]
1937	Machine tools	3	Contract	Terminated (1956)[362]
1938	Eyeglass frames	4	Contract	Terminated (1948)[363]
1938	Petroleum refining (hydrocarbon synthesis)	5	Contract[364]	Terminated (1942)[365]

356. *See id.* For press coverage, see *Appeal Is Expected on Hosiery Decision: Wholesalers Here Are 'Startled' by the Invalidation of 'Ringless' Patent*, N.Y. TIMES, Apr. 15, 1937, at 32; *Hosiery Men Fight Ringless Patent: Fifty Mill Representatives, at Meeting Here, Vote to Oppose Pool Control*, N.Y. TIMES, Mar. 19, 1935, at 30.

357. *An Agreement re Gas Polymerization Processes (Sept. 1, 1935) in Pooling of Patents: App. to Hearings on H.R. 4523 Before the H. Comm. on Patents*, 74th Cong. 3701–04 (1935).

358. United States v. Standard Oil Co., 1940–1943 Trade Cas. (CCH) ¶ 56,198 (D.N.J. 1942) (ordering by consent decree compulsory licensing of defendants' patents at zero royalty during the war and reasonable royalties thereafter).

359. United States v. Libbey-Owens-Ford Glass Co., 1948–1949 Trade Cas. (CCH) ¶ 62,323 (N.D. Ohio 1948) (requiring by consent decree that the three patentees in the pool grant non-exclusive royalty-free licenses to certain patents and reasonable royalty licenses to other patents).

360. United States v. Vehicular Parking, 54 F. Supp. 828 (D. Del. 1944) (noting, without stating an ultimate remedy, that the agreements would be enjoined and that the court would consider a government petition to mandate licensing of the patents to all applicants).

361. United States v. Kelsey-Hayes Wheel Co., 1955 Trade Cas. (CCH) ¶ 68,093 (E.D. Mich. 1951).

362. United States v. Mich. Tool Co., 1956 Trade Cas. (CCH) ¶ 68,290 (E.D. Mich. 1956) (terminating contractual agreements among defendants and ordering defendants to offer license, at reasonable royalty, to all applicants).

363. United States v. Am. Optical Co., 1948–1949 Trade Cas. (CCH) ¶ 62,308 (S.D.N.Y. 1948).

364. *See Analysis of the Hydrocarbon Synthesis Agreements in Patents: App. to Hearing on S. 2303 and S. 2491 Before the S. Comm. on Patents*, 77th Cong. 3800–07 (1942) (Gibson Exhibit Nos. 64–65).

365. United States v. Standard Oil Co., 1940–1943 Trade Cas. (CCH) ¶ 56,198 (D.N.J. 1942) (ordering by consent decree compulsory licensing of defendants' patents at zero royalty during the war and reasonable royalties thereafter).

Year Est.[293]	Market	No. of IP Holders-Members[294]	Arrangement[295]	Antitrust Outcome[296]
1938	Hormones	4	Contract	Terminated (1941)[366]
1939	Petroleum refining (sulfuric acid alkylation)	5	Contract[367]	Terminated (1942)[368]
1939	Performance rights (music, Broadcast Music, Inc.)	Approx. 300,000	Admin	Modified (1966)[369]
1941	Synthetic rubber	6	Contract	Modified (1942); Terminated (1949)[370]
1946	Elastic-top hosiery methods	4	Corp	Terminated (1952)[371]
1947	Process for converting	4	Contract	Upheld

366. United States v. Schering Corp., 1940–1943 Trade Cas. (CCH) ¶ 56,179 (D.N.J. 1941) (terminating information-exchange, market allocation, price-setting and certain other provisions of cross-licensing agreements but preserving rights of defendants in existing patents or patent licenses). For some of the underlying agreements, see *App. to Hearings Before a Subcommittee on the Committee on Military Affairs*, 78th Cong. 1141–55, 1166–69, 1189–93, 1194–99, 1200–03, 1205–08, 1209–56 (1943) (Berge Exhibit Nos. 191, 204, 213, 215, 217, 219, 221–235).

367. *See Alkylation Agreement (Apr. 12, 1939) in Patents: App. to Hearings on S. 2303 and S. 2491 Before the S. Comm. on Patents*, 77th Cong. 3874–92 (1942) (Gibson Exhibit No. 110).

368. United States v. Standard Oil Co., 1940–1943 Trade Cas. (CCH) ¶ 56,198 (D.N.J. 1942) (ordering by consent decree compulsory licensing of defendants' patents at zero royalty during the war and reasonable royalties thereafter).

369. BMI's rates and other policies have been subject to judicial review by consent decree since 1941, which was modified in 1966 and 1994. *See* United States v. Broad. Music, Inc., 1940–1943 Trade Cas. (CCH) ¶ 56,096 (E.D. Wis. 1941); United States v. Broad. Music, Inc., 1966 Trade Cas. (CCH) ¶ 71,941 (S.D.N.Y. 1966); United States v. Broad. Music, Inc., 1996-1 Trade Cas. (CCH) ¶ 71,378 (S.D.N.Y. 1994). Antitrust issues related to BMI's package licensing policy were addressed (and largely dismissed) in Broad. Music v. Columbia Broad. Sys., 441 U.S. 1 (1979).

370. The pool was established in 1941 shortly after Pearl Harbor by Standard Oil, which had formerly cross-licensed its patents with I.G. Farben, a German firm. In 1942, the pool's terms were modified pursuant to a consent decree, which required royalty-free licensing during war and reasonable royalties thereafter. United States v. Standard Oil Co., 1940–1943 Trade Cas. (CCH) ¶ 56,198 (D.N.J. 1942). In 1949, the Reconstruction Finance Corporation, operating pursuant to the Rubber Act of 1948, terminated the pool. *Patent Pool Ended in Synthetic Rubber*, N.Y. TIMES, Dec. 28, 1949 at 39; *Synthetic Rubber Wartime Patent Pool Arrangement is Ended*, WALL ST. J., Dec. 28, 1949, at 8.

371. United States v. Davis Co., 1952 Trade Cas. (CCH) ¶ 67,403 (S.D.N.Y. 1952) (ordering by consent decree that the patent holding company grant licenses on non-discriminatory terms). In an earlier civil litigation, the court found no antitrust violation and upheld the patentees' right to pursue infringement claims. *See* Baker-Commack Hosiery Mills v. Davis Co., 181 F.2d 550 (4th Cir. 1950).

Year Est.[293]	Market	No. of IP Holders-Members[294]	Arrangement[295]	Antitrust Outcome[296]
	citrus waste into stock feed			(1947)[372]
1947	Oil well servicing technology (jet process)	7	Contract	Terminated (1962)[373]
1948	Tractor cabs	3	Contract	Terminated (1953)[374]
1951	Telecommunications (including telephone, radio, aerial navigation)[375]	3	Contract	Not contested
1955	Anti-pollution technology for cars	5	Contract	Terminated (1969)[376]
1956	"Zigzag" sewing machines	3	Contract	Unknown (1963)[377]
1964	Synthetic yarn process	4	Contract	Terminated (1977)[378]
1977	Reproduction rights (literary material)	Approx. 12,000	Admin	Reviewed via business review letter (1993)[379]

372. Suni-Citrus Prods. Co. v. Vincent, 72 F. Supp. 740 (S.D. Fla. 1947) (upholding defendants' prospective patent pooling agreement).

373. United States v. Borg-Warner Corp., 1962 Trade Cas. (CCH) ¶ 70,461 (S.D. Tex. 1962) (ordering, by consent decree, that defendants terminate exclusive patent licenses and offer non-exclusive licenses to all applicants on reasonable uniform terms); *see also Government Charges 7 Oil Well Servicing Firms in Antitrust Suit*, WALL ST. J., July 28, 1961, at 6.

374. United States v. Bearing Distribs. Co., 1952–1953 Trade Cas. (CCH) ¶ 67,595 (W.D. Mo. 1953) (ordering by consent decree licensing of patents at reasonable royalties).

375. *Patent Pool Set Up in Communications*, N.Y. TIMES, June 7, 1951, at 39.

376. United States v. Auto Mfrs. Ass'n, 307 F. Supp. 617 (C.D. Cal. 1969), *aff'd per curiam sub nom.* New York v. United States, 397 U.S. 248 (1970) (approving consent decree requiring defendants to license air pollution control patents to all applicants on a royalty-free basis); In re Multidist. Vehicle Air Pollution, 367 F. Supp. 1298 (C.D. Cal. 1973) (dismissing private antitrust claim).

377. United States v. Singer Mfg. Co., 374 U.S. 174, 177–79 (1963) (finding an antitrust violation and remanding to the lower court for issuance of appropriate relief). There is no definitive information with respect to the final outcome.

378. Duplan Corp. v. Deering Milliken, Inc., 444 F. Supp. 648, 685–87, 772 (D.S.C. 1977).

379. In 1993, the Department of Justice issued a "business review letter" indicating no intention to challenge the pool's new nonexclusive blanket licensing policy. *See* Letter from Anne K. Bingaman, Assistant Att'y Gen., Antitrust Div., Dep't of Justice to R. Bruce Rich,

Year Est.[293]	**Market**	**No. of IP Holders-Members**[294]	**Arrangement**[295]	**Antitrust Outcome**[296]
Late 1990s[380]	Digital storage devices (CD-R, CD-RW)	4	Contract	Upheld (2010)[381]
1995	G.723.1 (videoconferencing/ telephony)	3	Admin	Not contested
1997	AAC (audio compression)	10	Admin	Not contested
1997	Video compression (MPEG-2 standard)	27	Admin	Reviewed via business review letter (1997)[382]
1998	Digital storage devices (3C DVD)	4	Contract; Admin	Reviewed via business review letter (1998);[383] private litigation (dismissed)[384]
1998	Bluetooth	7[385]	Admin	Not contested
1998	G.729 (audio data compression)	3	Admin	Not contested
1999	1394 (Firewire data transfer)	10	Admin	Not contested
1999	Digital storage devices (6C DVD)	9	Contract; Admin	Reviewed via business review letter (1999)[386]; private litiga-

Esq. (Aug. 2, 1993), http://www.justice.gov/atr/response-copyright-clearance-center-incs-request-business-review-letter [http://perma.cc/4U5N-YE8Q].

380. The date is approximate. Sources indicate that the pool has been in operation since the "late 1990s." *See* Princo Corp. v. Int'l Trade Comm'n, 616 F.3d 1318, 1323 (Fed. Cir. 2010).

381. *Id.* at 1319.

382. In 1997, the DOJ issued a "business review letter" indicating no intention to challenge the formation of the pool. *See* Letter from Letter from Joel I. Klein to Gerrard R. Beeney, *supra* note 80.

383. In 1998, the DOJ issued a "business review letter" indicating no intention to challenge the formation of the pool. *See* Letter from Joel I. Klein to Gerrard R. Beeney, *supra* note 286.

384. Wuxi Multimedia Ltd. v. Koninklijke Philips Elecs., N.V., 280 F. App'x 968 (Fed. Cir. 2008) (non-precedential order) (affirming district court's dismissal of antitrust suit against DVD-3C patent pool).

385. This refers to "promoter" members. *See* Bluetooth Special Interest Group, *Introduction to Membership*, BLUETOOTH https://www.bluetooth.org/en-us/members/introduction-to-membership [http://perma.cc/7SR8-FNK6].

386. *See generally* Letter from Joel I. Klein to Carey R. Ramos, *supra* note 154.

Year Est.[293]	**Market**	**No. of IP Holders-Members**[294]	**Arrangement**[295]	**Antitrust Outcome**[296]
				tions (upheld or settled)[387]
2001	Video storage and streaming (MPEG-4 visual standard)	29	Admin	Reviewed via business review letter (2002)[388]
2001	Interactive TV programs (OpenCable Application Platform) (OCAP tru2way)	6	Admin	Not contested
2002	Wireless communication networks (W-CDMA FDD 3GPP)	14	Admin	Reviewed via business review letter (2002)[389]
2003	Audio/video compression (MPEG-4 systems)	8	Admin	Not contested[390]
2003	Audio coding (MPEG-2 AAC)	6	Admin	Not contested
2003	Performance rights for non-interactive digital transmissions of copyrighted sound recordings	Approx. 43,000	Admin	Authorized by statute and regulations[391]
N/A	Audio compression (AMR-NB)[392]	4	Admin	Not contested
2004	Audio compression	1	Admin	Not contested

387. *See* Matsushita Elec. Indus. Co., v. Cinram Int'l, Inc., 299 F. Supp. 2d 370 (D. Del. 2004) (upholding the pool). Other civil antitrust litigation was brought but settled out of court. *See* Nero AG v. MPEG LA, L.L.C., No. 10-cv-3672-MRP-RZ2010, 2010 WL 4366448 (C.D. Cal. Sept. 14, 2010); Press Release, MPEG LA, L.L.C., MPEG LA, Nero Settle Litigation (July 11, 2012), http://www.mpegla.com/Lists/MPEG%20LA%20Legal%20Action%20List/Attachments/47/n-12-04-12.pdf [http://perma.cc/NWE7-LXEZ].

388. In 2002, the DOJ issued a "business review letter" indicating no intention to challenge the formation of the pool. *See* Letter from Charles A. James to Ky P. Ewing, *supra* note 286.

389. In 2002, the DOJ issued a "business review letter" indicating no intention to challenge the formation of the pool. *See id*.

390. Allegations that MPEG LA violated its agreement with the DOJ resulted in a DOJ investigation. *See* Jason Rantanen, *Guest Post on Patent Pools and Competition*, PATENTLY-O (Mar. 1, 2013), http://patentlyo.com/patent/2013/03/guest-editorial-on-patent-pools-and-competition.html [http://perma.cc/PTX9-ZGHE]. However, the investigation was apparently abandoned.

391. *See* Notice of Designation as Collective, 37 C.F.R. § 370.5 (2010).

392. This is based on information on VoiceAge's archived website, as of 2007. *AMR Licensees*, VOICEAGE, http://web.archive.org/web/20071014162355/http://www.voiceage.com/amr_licensees.php [http://perma.cc/X47N-XTXR].

Year Est.[293]	Market	No. of IP Holders-Members[294]	Arrangement[295]	Antitrust Outcome[296]
	(AMR-WB+)[393]			
2004	Video coding (AVC/H.264) (MPEG-4 Part 10)	35	Admin	Not contested[394]
2005	Digital rights management (Digital Radio Mondiale)	10	Admin	Not contested
2005	Ethernet networking (IEEE 802.11)	4	Admin	Reviewed via business review letter (2006)[395]
2006	Audio/video streaming (MPEG-2 Systems)	10	Admin	Not contested
2007	Video compression (VC-1)	20	Admin	Not contested
2007	Digital television (ATSC)	9	Admin	Private litigation[396]
2007	Speech and audio coding (G.729.1)	9	Admin	Not contested
2008	Reference Technology (AGORA-C)	4	Admin	Not contested
2008	Digital television (DVB-T)	4	Admin	Not contested
2008	Audio compression (MPEG Surround)	7	Admin	Not contested
2008	Telephony (G.711.1)	5	Admin	Not contested

393. This pool formerly included more than two licensors. *See Licensors*, VOICEAGE, https://web.archive.org/web/20071014162141/http://www.voiceage.com/amrwbplus_licensors.php [https://perma.cc/D6F2-WS48] (Internet Archive VoiceAge Licensing Page for the AMR-WB+ Patent Pool). Hence I have retained it even though it currently only services one licensor (Orange S.A.). *See Extended Adaptive Multi-Rate–Wideband*, WORLD PUBLIC LIBRARY, http://www.worldlibrary.org/articles/Extended_Adaptive_Multi-Rate_%E2%80%93_Wideband [http://perma.cc/E24E-4SMT].

394. The DOJ initiated an antitrust investigation with respect to this pool. However, the investigation was apparently dropped once the administrator agreed to provide a license to Google (who wished to develop an alternative standard) with respect to the use of certain patents in the pool. *See* Ed Bott, *Google and MPEG LA Settle Long-Running VP8/H.264 Patent Dispute*, ZDNET (Mar. 7, 2013, 12:17 PM), http://www.zdnet.com/article/google-and-mpeg-la-settle-long-running-vp8h-264-patent-dispute [http://perma.cc/B9ZU-NJ7A].

395. Via Licensing is responsible for licensing the IEEE 802.11 standard, but the IEEE arrangement in general was reviewed by the DOJ. *See* Letter from Thomas O. Barnett, Acting Assistant Att'y Gen., Antitrust Div., Dep't. of Justice, to Michael A. Lindsay, Esq. (April 30, 2007), http://www.justice.gov/sites/default/files/atr/legacy/2007/04/30/222978.pdf [http://perma.cc/B8WY-5U34].

396. *See* Vizio, Inc. v. Funai Elec. Co., No. CV-09-0174-AHM(RCx), 2010 WL 7762624 (C.D. Cal. Feb 3, 2010).

Year Est.[293]	Market	No. of IP Holders-Members[294]	Arrangement[295]	Antitrust Outcome[296]
2009	Video and audio encoding (MPEG-4 SLS)	3	Admin	Not contested
2009	Digital television (DVB-T2)	9	Admin	Not contested
2010	Audio compression (AMR-WB/G.722.2)[397]	1	Admin	Not contested
2010	Blu-Ray (Premier BD)	6	Admin	Not contested
2010	RFID Consortium	5	Admin	Reviewed via business review letter (2007)[398]
2011	One-Blue (Blu-Ray)	16	Admin	Not contested
2012	LTE (4G)	7	Admin	Not contested
2012	3D video (MVC)	19	Admin	Not contested
2013	Video compression (H.264 SVC)	3	Admin	Not contested
2013	LTE (4G)[399]	13	Admin	Not contested
2013	Healthcare diagnostics and tools (Librassay)	9	Admin	Not contested
2014	Video compression (HEVC)	32	Admin	Not contested
2015	Digital display interface (DisplayPort)	4	Admin	Not contested

397. This pool formerly included more than two licensors. *See Licensors*, VOICEAGE, http://web.archive.org/web/20100130035805/http://www.voiceage.com/licamrwb_licensors.php [http://perma.cc/9BKJ-5L59] (Internet Archive VoiceAge Licensing Page for the AMR-WB/G722.2 Patent Pool). Hence I have retained it even though it currently only services one licensor (Orange S.A.). *See AMR-WB/G722.2*, VOICEAGE, http://www.voiceage.com/AMR-WB.G.722.2.html [http://perma.cc/MY8V-EBT7].

398. *See* Letter from Thomas O. Barnett, Acting Assistant Att'y Gen., Antitrust Div., Dep't. of Just., to William F. Dolan and Geoffrey Oliver (Oct. 21, 2008), http://www.justice.gov/sites/default/files/atr/legacy/2008/10/21/238429.pdf [http://perma.cc/3ZYT-E29U].

399. This differs from the "4G" standard established in 2012 because it is administered by Via Licensing, whereas the 2012 pool is administered by SISVEL. *See Long Term Evolution – LTE*, VIA LICENSING, http://www.vialicensing.com/lte/index.aspx [http://perma.cc/H9S2-YSQ3]; *LTE/LTE-A*, SISVEL, http://www.sisvel.com/index.php/lte-ltea [http://perma.cc/N6A4-8M8U].