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PATENT POOLS AND CUMULATIVE INNOVATION

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ABSTRACT

The movement about open access to scientific knowledge has inspired many important discussions among policy makers. Under the backdrop of this movement is an increasing realization that the trajectory of innovation for modern technologies is cumulative as new innovations rely on taking advantage of what came before. Institutional theories have identified two essential requirements for cumulative innovation: disclosure and access. In 1962, Kenneth Arrow first recognized that the patent marketplace is an important venue where exchanges of innovative ideas occur. However, because of high transaction costs in patent licensing, access to patented knowledge is often impeded. Previous literatures have largely focused on modifications to patent law doctrines, such as patent scope or infringement remedy, to promote cumulative innovation. This article instead argues that a patent pool, a different type of institution for innovation, can spur cumulative innovation by facilitating access to patented knowledge. The article explains that a patent pool

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reduces transaction costs of patent licensing by aggregating related patents and centralizing licensing negotiations. Moreover, because creating a patent pool as a common knowledge space requires collaboration among patent owners, the success of a patent pool often depends on whether patent owners can overcome collaborative failures. The collective action theory, which identifies appropriation and provision as two essential issues for collaboration, provides the basic framework for the design of patent pools. This article will then offer three main design suggestions: (1) appropriation limitation is not necessary for the long-term sustainability of a patent pool; (2) in order to induce patent owners to join a patent pool, a patent pool should establish mechanisms that fairly allocate licensing revenue and reduce transaction costs of licensing; and (3) grant-back provisions are desirable to prevent a patent pool from becoming obsolescent.

Keywords: patent pool, cumulative innovation, patent marketplace, transaction costs, the collective action theory, collective enforcement, grant-back provisions

INTRODUCTION

Designing effective institutions to facilitate innovation is challenging because the processes of innovation has some peculiar economic characteristics, one of which is its cumulative nature—technological advancements rely substantially on the access to past innovations.[1] Technological trajectories in many industries, such as semiconductors or biotechnology, have largely corroborated the theory of cumulative innovation.[2] Because cumulative innovation does not happen in a vacuum, appropriate legal, social, or organizational structures are necessary to support it.[3]

Kenneth Arrow, in a groundbreaking article in 1962, first introduced the idea that the patent system creates a market for exchanges of innovative knowledge.[4] Arguably, patents would create a marketplace where patentable knowledge could be traded through patent licenses and the market mechanism would then provide an efficient allocation of resources for innovations.[5] However, both theoretical modeling and empirical studies have shown the patent marketplace, which is built on individualistic control of property rights, is riddled with inefficiencies that hinder access to prior

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[1] *See* Arti K. Rai, *Fostering Cumulative Innovation in the Biopharmaceutical Industry: The Role of Patents and Antitrust*, 16 BERKELEY TECH. L. J. 813, 828-38 (2001) (describing the process of cumulative innovation in the biopharmaceutical industry).

[2] *See* Richard C. Levin, *The Semiconductor Industry, in* GOVERNMENT AND TECHNICAL PROGRESS: A CROSS-INDUSTRY ANALYSIS 76 (Herbert I. Fusfeld & Richard R. Nelson eds., 1982) (describing that the semiconductor industry was marked by rapid cumulative innovations growing out of basic research).

[3] *See* Fiona Murray & Siobhan O'Mahony, *Exploring the Foundations of Cumulative Innovation: Implications for Organization Science*, 18 ORG. SCI. 1006, 1006 (2007) ("Such accumulation is not inherent to the innovation process but can be either supported or limited by the context in which it occurs.").

[4] *See* Kenneth Arrow, *Economic Welfare and The Allocation of Resources for Invention*, THE RATE AND DIRECTION OF INVENTIVE ACTIVITY: ECONOMIC AND SOCIAL FACTORS 609, 617 (1962) (arguing that patents encourage information disclosure and facilitate information exchange). In this paper, Arrow shifted the focus from product markets to markets for *information*, in keeping with his research agenda at the time. *Id.* Patents became, in Arrow's hands, a mechanism for encouraging information disclosure. *Id.* Without such protection, the buyer of information, who presumably needs access to it to determine its worth, would never pay anything; or else, she would have to be content to buy it without seeing it – an arrangement not conducive to a robust market. *Id. See also* Robert P. Merges, *Institutions for Intellectual Property Transactions: The Case of Patent Pools* 4 (U.C. Berkeley Sch. of Law, 1999).

[5] *See* Daniel F. Spulber, *How Patents Provide the Foundation of the Market for Inventions*, 11 J. OF COMPETITION L. & ECON. 271, 283 (2015) (describing how patents support the establishment of the market for innovation); Zorina B. Khan & Kenneth L. Sokoloff, *Institutions and Democratic Invention in 19th-Century America: Evidence From "Great Inventors," 1790-1930*, 94 AMER. ECON. REV. 395, 395 (2004) (highlighting the impact of early U.S. patent institutions in providing broad access to economic opportunity and in encouraging trade in new technological knowledge).

innovations.[6] Legal scholars and economists have focused on changing patent law doctrines, such as patent scope or patent remedy, as a solution.[7] For example, Professor Mark Lemley and Professor Carl Shapiro argued that a stay of injunctive relief, sufficient to allow an infringer to design around patents, would significantly reduce the bargaining power of patent owners to charge excessive licensing fees.[8]

This article argues that a different type of institution for innovation—the patent pool— can better promote cumulative innovation than the traditional patent marketplace by reducing transaction cost of patent licensing and improving access to patented knowledge. A patent pool can be defined as an agreement whereby multiple patent owners aggregate their patents under an agreed-on governance structure to facilitate patent licensing.[9] In contrast to the traditional patent marketplace, a patent pool represents a collective action model for cumulative innovation.[10] This article also argues that because an innovation-promoting patent pool entails collaboration of multiple patent owners with potentially divergent interests, careful and deliberate design is necessary to reduce potential collaborative failures. This article is composed of four sections. Section I outlines structural conditions for cumulative innovation. Section II argues that patent pools can better promote cumulative innovation. Section III introduces the collective action theory and analyzes several design issues for patent pools. Section IV provides a conclusion.

I. CUMULATIVE INNOVATION

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[6] *See* Arrow, *supra* note 4, at 615 ("Legally imposed property rights can provide only a partial barrier, since there are obviously enormous difficulties in defining in any sharp way an item of information and differentiating it from other similar sounding items.").

[7] *See generally* Robert P. Merges & Richard R. Nelson, *On the Complex Economics of Patent Scope*, 90 COLUM. L. REV. 839 (1990) (analyzing the impact of broad patent scope on the environment for subsequent development and improvement in various industries); Mark Lemley & Carl Shapiro, *Patent Holdup and Royalty Stacking*, 85 TEX. L. REV. 1991 (2007) (discussing the issue of royalty stacking and providing suggestions for patent reform in the United States).

[8] Lemley & Shapiro, *supra* note 7, at 2035-39 (recommending a stay of injunctive relief as a solution to patent holdup).

[9] Steven C. Carlson, *Patent Pools and The Antitrust Dilemma*, 16 YALE J. ON REG. 359, 367 (1999) ("Patent pools are private contractual agreements whereby rival patentees transfer their rights into a common holding company for the purpose of jointly licensing their patent portfolios.").

[10] *See* Shubha Ghosh*, How to Build a Commons: Is Intellectual Property Constrictive, Facilitating, or Irrelevant?*, *in* UNDERSTANDING KNOWLEDGE AS A COMMONS 222 (Charlotte Hess & Elinor Ostrom eds., 2007) (describing a patent pool as a self-regulating mechanism for the dissemination of patented knowledge by a group of patent owners).

Isaac Newton's self-reflective statement from two hundred years ago—"If I have seen further, it is by standing upon the shoulders of [g]iants"—encapsulates the essence of cumulative innovation.[11] At a 1996 Federal Trade Commission hearing on new technologies, the Nobel-winning economist Joseph Stiglitz declared that now "we have an innovation system in which one innovation builds on another."[12] This section analyzes both the reasons and conditions for cumulative innovation. Subsection A explains, from a technological standpoint, why cumulative innovation becomes increasingly common. Subsection B examines its two necessary conditions.

A. Cumulative Innovation in Complex Systems

Cumulative innovation underscores the path of technological development in many "complex system" industries.[13] Economist Herbert A. Simon defines a complex system as a system "made up of a large number of parts that interact in a non-simple way."[14] In essence, "complexity" derives from both the sheer number of discrete parts comprising the system and the nature of the interconnections among those parts. The following figure illustrates a three-component complex system.

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[11] *See* Letter from Isaac Newton to Robert Hooke (February 5, 1675), *in* 1 DAVID BREWSTER, MEMOIRS OF THE LIFE, WRITINGS, AND DISCOVERIES OF SIR ISAAC NEWTON 142 (1855).

[12] FED. TRADE COMM'N, ANTICIPATING THE 21ST CENTURY, COMPETITION POLICY IN THE NEW HIGH-TECH, GLOBAL MARKETPLACE 6 (1996), https://www.ftc.gov/system/files/documents/reports/anticipating-21st-century-competition-policy-new-high-tech-global-marketplace/gc_v1.pdf.

[13] *See* Alberto Galasso & Mark Schankerman, *Patents and Cumulative Innovation: Causal Evidence From the Courts*, 130 Q. J. ECON. 317, 318 (2014) (arguing that the increasing proliferation of patents, and the fragmentation of ownership among firms are particularly acute in 'complex technology' industries where innovation is highly cumulative).

[14] *See* Herbert A. Simon, *The Architecture of Complexity*, 106 PROCEEDINGS AM. PHILOSOPHICAL SOC'Y 467, 468 (1962) ("Roughly, by a complex system I mean one made up of a large number of parts that interact in a non-simple way.").

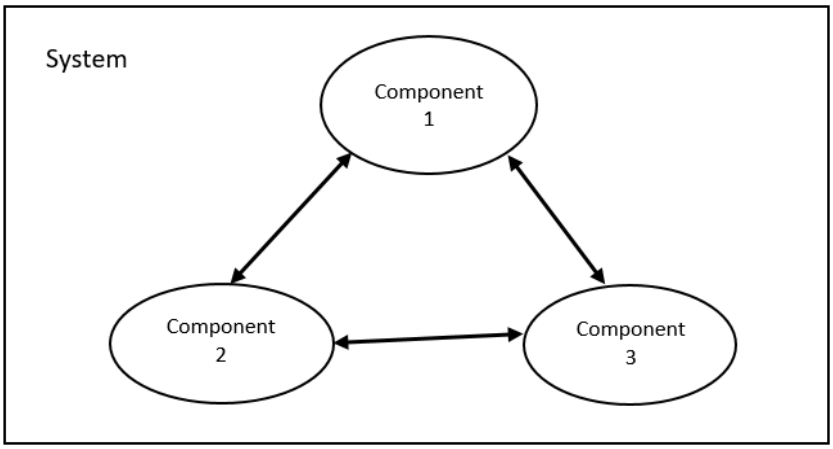

Figure 1: A Three-Component Complex System

"Complexity" has significant implications for a firm's decision-making on innovations. Firstly, most firms choose to modularize innovations by optimizing discrete components of a system because modular innovations are more cost-effective.[15] In addition, modular innovations are more rapidly adopted because they do not cause an unexpected disruption in the functioning of the overall system.[16] Herbert Simon famously commented: "If, around the turn of the century, we wanted to instruct a workman to make an automobile, perhaps the simplest way would have been to tell him how to modify a wagon by removing the singletree and adding a motor and transmission."[17] However, although modularization brings about many benefits, it tends to make access to past modular innovations imperative for any system-level improvements. Following with Simons' example, if an automaker desires to conduct a system-level innovation such as improving its automobile's fuel efficiency, working with outdated motors and transmissions will be

[15] *See* Richard N. Langlois, *Modularity in Technology and Organization*, 49 J. ECON. BEHAV. & ORG. 19, 23-24 (2002) ("Clearly, modularity is a design structure with a great many advantages. By reducing the degree of interdependency among, and thus the costs of communicating across, the parts of a system, it gives full rein to the many benefits of the division of labor.").
[16] *See* Sendil K. Ethiraj & Daniel Levinthal, *Modularity and Innovation in Complex Systems*, 50 MGMT. SCI. 159, 169 (2004) ("[M]aking innovation decisions on larger modules creates greater constraints on innovation because of the potentially larger number of interactions of each decision variable with other decision variables in the same module. This not only reduces the frequency of successful local search, but also reduces the likelihood of adopting innovations that would reduce overall performance as a result of ignoring the presence of interactions among decisions choices.").
[17] *See* Simon, *supra* note 14, at 480.

counterproductive. Secondly, because discrete components are interconnected in a complex system, innovations on one component requires knowledge about developments on other components.[18] For example, in the drug development process, two important interdependent components are drug compounds, which contain active pharmaceutical ingredients, and synthetic protein molecules as drug receptors.[19] Breakthroughs on drug compounds rely heavily on access to innovations on receptors because vitro studies at the pre-clinical stage require drug compounds to be screened against a variety of receptors associated with different diseases to determine whether they have any side effects.[20]

B. Conditions for Cumulative Innovation

Economic historian Joel Mokyr argued that technological advances in Western civilization in the last two centuries were driven to a great extent by improved access to prior innovative ideas in society at large.[21] Mokyr's logic goes like this: if access costs are low, the chance of losing an existing piece of knowledge is small, and the innovative efforts will more likely result in the expansion of knowledge space as opposed to "reinventing the wheel."[22] Legal scholars and institutional economists have concluded there are two main conditions for cumulative innovation: (1) disclosure and (2) access.[23]

1. Disclosure

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[18] *See* Langlois, *supra* note 15, at 21 ("In a non-decomposable system, the successful operation of any given part is likely to depend on the characteristics of many other parts throughout the system."). *See also* Lee Fleming & Olav Sorenson, *Navigating the Technology Landscape of Innovation*, 44 MIT SLOAN MGMT. REV. 15, 17 (2003) (discussing coupling between components).

[19] *See* Rai, *supra* note 1, at 816 (discussing the drug development process).

[20] *See* Christopher M. Holman, *Inside Views: Why Follow-On Pharmaceutical Innovations Should Be Eligible For Patent Protection*, Intellectual Property Watch (last visited Oct. 23, 2018), http://www.ip-watch.org/2018/09/21/follow-pharmaceutical-innovations-eligible-patent-protection/.

[21] *See* JOEL MOKYR, THE GIFTS OF ATHENA: HISTORICAL ORIGINS OF THE KNOWLEDGE ECONOMY 104 (2002) (arguing that the growth explosion in the modern west in the last two centuries was the outcome of the appearance of new technological ideas as well as the improved access to these ideas in societies).

[22] *See id.* at 8 (arguing that access costs determine how likely new discoveries will be cumulative in nature and expand existing knowledge space).

[23] *See* Murray & O'Mahony, *supra* note 3, at 1009-13 (outlining an analytical framework for cumulative innovation).

To cumulatively build on the ideas that "came before," innovators need to have actual knowledge about what are the previous ideas.[24] A sequential innovator's search cost for previous ideas is a major hurdle to cumulative innovation. Thus, disclosure, which significantly reduces search costs, is a first step.[25] Without disclosure, sequential innovators may very well end up engaging in socially-wasteful duplicative research.[26]

Disclosure can take place through different mechanisms such as academic publications, patents, or private communications.[27] The technicalities of disclosure can vary considerably depending on the mechanism an innovator chooses. For example, patent laws generally impose a legal standard on the sufficiency of disclosure, which will be discussed more extensively in Section II.[28] Academic publications often demand detailed descriptions of scientific methods so that independent researchers can verify the results with the described experiments or calculations. Moreover, innovators may opt for a confidential communication with relevant parties about their innovations. Generally speaking, public disclosure, such as patents or academic publications, relies on established social norms or legal precedents, whereas private disclosure is governed by negotiations among parties.

2. Access

Disclosure does not guarantee that sequential innovators will have access to prior innovative knowledge, which is essential for cumulative innovation. In many cases, innovators, even after disclosure, can still exert control over their inventions through legal or technical means to prevent

[24] *See id.* at 1009 ("[T]o cumulatively build on the ideas that 'came before,' the innovator must know what came before.").
[25] *See* Spulber, *supra* note 5, at 284 (arguing that disclosure reduces the information costs to other inventors who can learn about prior art).
[26] *See id.* at 285 (arguing that disclosure also helps to avoid duplicating prior researches).
[27] *See* Partha Dasgupta & Paul A. David, *Toward a New Economics of Science*, 23 RESEARCH POLICY 487, 495-503 (1994) (describing the different disclosure mechanisms based on whether the innovative knowledge is public or private).
[28] *See* discussion *infra*, text accompanying notes 37-47.

others from effectively using them.[29] A patent owner has the legal right to exclude others from practicing the inventions claimed in the issued patents.[30] In addition, technologies can be utilized to deter access. Product manufacturers who disclose their innovations by incorporating them into their products can invest in anti-reverse engineering tools so that others cannot obtain their "secret sauce".[31] Copyright owners have long used hardware or encryption systems to control access to their copyrighted digital material.[32] Their efforts were further aided by the Digital Millennium Copyright Act of 1998, which criminalizes the distribution of tools used for circumvention of these systems.[33]

The decision of whether to grant access is, under most circumstances, a private decision based on an innovator's cost-benefit calculations. Innovators may condition access on receipt of monetary payment to compensate for their prior innovative efforts and investments. In some cases, it can be beneficial for innovators to offer free access. For example, a game console manufacturer, who is in a two-sided market, may find it profitable to give game developers free access to its patented application programming interfaces so that these developers can design compatible games. Although granting free access costs the console manufacturer licensing revenues, the expected rise in the number of compatible games can increase consumer demand for the consoles, thus offsetting the loss of licensing revenues.[34]

II. PATENT MARKETPLACE AND PATENT POOLS

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[29] *See* Murray & O'Mahony, *supra* note 3, at 1011 ("Innovators exert control over access to their ideas using legal, normative, or technical mechanisms operating at institution, field, organization, and community levels.").
[30] *See* 35 U.S.C § 271 (2010).
[31] *See* JAMES POOLEY, TRADE SECRETS § 5.02[5], at 5-25 (1997). It may also be possible to build products that are difficult to break down and copy. *Id.* Hardware components can be encapsulated to make nondestructive disassembly almost impossible; components can be mislabeled ...; custom parts can be used; "locks" (often implemented in software) can be added . . . . *Id.* In any sort of complex product, nonfunctional features can be added to create a "fingerprint" on any illegitimate copy, forcing copyists to invest in real reverse engineering efforts. *Id.*
[32] *See* Pamela Samuelson & Suzanne Scotchmer, *The Law and Economics of Reverse Engineering*, 111 YALE L.J. 1575, 1630-46 (2001) (discussing the use of technology to prohibit reverse-engineering of digital contents).
[33] *See* 17 U.S.C. § 1201(a)(1) (2012) (prohibiting the circumvention of access controls of protected material); *id.* at (a)(2) (prohibiting the distribution of tools enabling the circumvention).
[34] *See* Jean-Charles Rochet & Jean Tirole, *Two-sided Markets: A Progress Report*, 37 RAND J. OF ECON. 645, 645 (2006) ("Videogame platforms, such as Atari, Nintendo, Sega, Sony Play Station, and Microsoft X-box, need to attract gamers in order to persuade game developers to design or port games to their platform, and they need games to induce gamers to buy and use their videogames console.").

The patent marketplace, which is built on a property rights regime of innovations, plays a crucial role in cumulative innovation.[35] Although the patent marketplace has grown steadily as the rise in the global annual patent licensing revenue will indicate, it has many inefficiencies.[36] This section will argue patent pools promote cumulative innovation more effectively than the traditional patent marketplace because they reduce transaction costs associated with gaining access to patented knowledge. This section is composed of two subsections. Subsection A will describe how the patent market place deals with disclosure and access. Subsection B will examine the inefficiencies in the patent marketplace and then analyze how patent pools solve those inefficiencies.

A. The Patent Marketplace

1. Disclosure

Thomas Jefferson famously commented about innovation in his letter to U.S. representative Isaac Mcpherson in 1813.

> If nature has made any one thing less susceptible than all others of exclusive property, it is the action of the thinking power called an idea, which an individual may exclusively possess as long as he keeps it to himself; but the moment it is divulged, it forces itself into the possession of everyone, and the receiver cannot dispossess himself of it. Its peculiar character, too, is that no one possesses the less, because every other possesses the whole of it. He who receives an idea from me, receives instruction himself without lessening mine; as he who lights his taper at mine, receives light without darkening me.[37]

Jefferson eloquently stated that knowledge, as the fruit of innovations, is both non-rivalrous and non-excludable.[38] Knowledge is non-rivalrous because one's use of knowledge does not reduce its

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[35] *See* Clarisa Long, *Patents and Cumulative Innovation*, 2 WASH. U. J.L. & POL'Y 229, 230 (2000) (arguing that because a patent marketplace is essential to cumulative innovation, constructing "dynamic, rather than static, models of proprietary rights" for the patent system is important).
[36] *See* Anne Kelley, *Practicing in The Patent Marketplace*, 78 U. CHI. L. REV. 115, 116 (2011) ("[T]he global patent sale marketplace, which fuels both these offensive and defensive strategies, is estimated to generate only $1.2 billion per year.").
[37] *See* Letter from Thomas Jefferson to Representative Isaac McPherson (1813), https://founders.archives.gov/documents/Jefferson/03-06-02-0322.
[38] ROBERT COOTER & THOMAS ULEN, LAW AND ECONOMICS 126 (3d ed. 2000).

availability to others.[39] In addition, knowledge is non-excludable because, once knowledge is disclosed, it is prohibitively costly to exclude others from using the knowledge.[40] The following matrix illustrates a classification of goods based on rivalry and excludability.

	Excludable	Non-Excludable
Rivalrous	Private Goods • Car	Commons Goods • Fish in the open sea
Non-Rivalrous	Club Goods • Gym	Public Goods • Knowledge

Figure 2: Classification of Goods Based on Rivalry and Excludability

Because new knowledge can be easily appropriated after it is disclosed, innovators have strong incentives to keep it a secret.[41] The theory of public goods informs that a legal regime that prohibits unauthorized appropriation is necessary to incentivize disclosure. Patent laws encourage disclosure by granting a patent owner a statutory right to exclude others from using the patented knowledge.[42] In return for the exclusive right of use, a patent applicant is obligated to disclose the invention publicly through a patent application, which paves the way for the patent marketplace.[43] From a social welfare perspective, early disclosure is more efficient than late disclosure because it reduces the time lapse between original innovations and follow-on innovations. The "first to file" rule in the patent system, which gives the exclusive right to whoever files a patent application first, incentivizes early disclosure.[44]

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[39] *Id.*
[40] *Id.*
[41] Amy Kapczynski & Talha Syed, *The Continuum of Excludability and the Limits of Patents*, 122 YALE L.J. 1900, 1909 (2013) ("One way to exclude others from information is to use simple secrecy.").
[42] Aronson v. Quick Point Pencil Co., 440 U.S. 257, 262 (1979) (holding that the patent system promotes disclosure of inventions to stimulate further innovation and to permit the public to practice the invention once the patent expires).
[43] 35 U.S.C. § 112 (2012). *See also* Spulber, *supra* note 5, at 284 ("Disclosure provides a description of the invention, the list of claims and other information in the patent that is useful for transactions.").
[44] *See generally* Mark Lemley & Colleen Chien, *Are the U.S. Patent Priority Rules Really Necessary?*, 54 HASTING L.J. 1299 (2002) (discussing the first to file system).

Furthermore, patent laws also set the standard for disclosure. For example, U.S. patent laws require that the disclosures enable a person having ordinary skills in the art to make and use the disclosed invention ("the enablement requirement").[45] The standardization of disclosure serves at least two important purposes. First, it ensures that the invention is communicated in such a way that the interested public, including sequential innovators, can use the invention with reasonable efforts.[46] Second, the detailed and accurate disclosure required by patent laws mitigates against the adverse selection in bargaining, which can result in a failure to reach a mutually-beneficial agreement.[47] Adverse selection often occurs when there is an information asymmetry between transacting parties. Generally speaking, patent owners have better information about their innovations than other parties in the marketplace. Detailed descriptions of innovations through patent applications reduce the information asymmetry, thus rendering the sale, or licensing of the inventions, more efficient.[48]

2. Access

In general, there are two types of mechanisms for access to patented knowledge in the patent marketplace: legally-mandatory mechanisms and permissive mechanisms. Mandatory mechanisms include compulsory patent licensing where a sovereign state requires a patent holder to

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[45] *See* Monsanto Co. v. Syngenta Seeds, Inc., 503 F.3d 1352, 1360 (Fed. Cir. 2007) (interpreting 35 U.S.C. § 112).
[46] *See* Alison E. Cantor, *Using the Written Description and Enablement Requirements to Limit Biotechnology Patents*, 14 HARV. J.L. & TECH. 267, 280–310 (2000) (discussing the enablement and written-description requirements of 35 U.S.C. § 112).
[47] *See* Spulber, supra note 5, at 285 ("Disclosure to the USPTO also mitigates adverse selection in bargaining between inventors and adopters. Adverse selection in bargaining can result in the failure of a buyer and a seller to come to an agreement, even though the transaction would offer gains from trade. When the quality of the seller's good is observable to the buyer but not to the seller, the seller's offer may not be sufficient to compensate the buyer. Disclosure increases the information about inventions available to potential adopters, thus reducing asymmetry of information in negotiations between inventors and adopters.").
[48] *See id.* at 288 ("In general, standardization can improve the efficiency of markets. Standardization allows buyers and sellers to focus their attention on the idiosyncratic features of the transaction at hand. Standardization allows for economies of scale in transactions. Also, standardization allows buyers and sellers to make comparisons with other transactions, thus facilitating competition. Standard definitions of terms lower the costs of communication and negotiation."). *See* Deepak Hegde & Hong Luo, *Patent Publication and the Market for Ideas*, (Harv. Bus. Sch., Working Paper 14-019, 2016), for some empirical evidence showing that by requiring inventions to be published through a credible, standardized, and centralized repository, it mitigates information costs for buyers and sellers and, thus, facilitates transactions in the market for ideas.

license its patents to others.[49] Advocates for compulsory patent licensing argue that it would reduce patent non-use and allow highest-value users to commercialize on new technologies.[50] Although the majority of World Trade Organization ("WTO") member nations have fully embraced patent compulsory licensing,[51] the Supreme Court of the U.S. has unequivocally held that U.S. patent law does not obligate patent owners to license their inventions on the rationale that the threat of compelled licensing weakens patent rights and reduces the incentives to develop new inventions.[52]

In limited cases, competition concerns may compel grant of access. U.S. antitrust law adopts a narrowly-defined essential facilities doctrine, which holds that a firm, found to own a facility essential to competition in a relevant market, is required to provide reasonable use of that facility to competitors, unless some conditions preclude it from sharing access.[53] For example, in *MCI Communications v. AT&T Co*, AT&T refused to connect a long distance communication carrier MCI into its local distribution facilities.[54] The Seventh Circuit Court of Appeals concluded that the essential facilities doctrine was applicable to AT&T because it had complete control over the local distribution facilities that were economically infeasible for MCI to duplicate and the interconnections were essential for MCI to offer a competing private line services against AT&T.[55]

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[49] *See* Sara M. Ford, *Compulsory Licensing Provisions Under the TRIPs Agreement: Balancing Pills and Patents,* 15 AM. U. INT'L L. REV. 941, 945 (2000) ("Compulsory licensing is defined generally as the granting of a license by a government to use a patent without the patent-holder's permission.").

[50] *See* Pankaj Tandon, *Optimal Patents with Compulsory Licensing*, 90 J. POLIT. ECON. 470, 470 (1982) (arguing for the use of compulsory licensing as a policy tool to combat the monopoly problem associated with the patent system).

[51] Under Article 5 of the Paris Convention, member countries may grant compulsory licenses to prevent abuse that may result from a patent holder's exercise of exclusive patent rights. *See* Paris Convention for the Protection of Industrial Property art. 5(A)(2)-(4), Sept. 28, 1979, 21 U.S.T. 1583, 828 U.N.T.S. 305.

[52] *See* Dawson Chem. Co. v. Rohm & Haas Co., 448 U.S. 176, 215 (1980) ("Compulsory licensing is a rarity in our patent system, and we decline to manufacture such a requirement out of § 271(d).").

[53] *See* Eastman Kodak Co. v. Image Tech. Servs., Inc., 504 U.S. 451, 483 n. 32 (1992) ("It is true that as a general matter a firm can refuse to deal with its competitors. But such a right is not absolute; it exists only if there are legitimate competitive reasons for the refusal."); Lorain Journal Co. v. United States, 342 U.S. 143, 155 (1951) (holding that right to refuse to deal is not exempt from regulation). *See also* Robert Pitofsky, Donna Patterson & Jonathan Hooks, *The Essential Facilities Doctrine Under United States Antitrust Law*, 70 ANTITRUST L.J. 443, 461 (2002) (arguing that application of the essential facility doctrine is appropriate in exceptional circumstance where a facility is truly essential to competition).

[54] *See* MCI Comm'ns v. AT&T Co., 708 F.2d 1081, 1132-33 (7th Cir. 1983).

[55] *Id.*

Furthermore, the experimental use exception is another example of mandatory access.[56] U.S. Courts have recognized that a purely "experimental use" of a patented invention with no commercial purpose is exempt from infringement liability.[57] In *Whittemore v. Cutter*, Justice Story wrote: "it could never have been the intention of the legislature to punish a man, who constructed … a [patented] machine merely for philosophical experiments, or for the purpose of ascertaining the sufficiency of the machine to produce its described effects."[58] Over the years, courts significantly narrowed the experimental use defense.[59] However, advocates for broadening the scope of the experimental use defense have argued that the defense promotes academic research and cumulative innovation by providing sequential innovators with an important channel of free access to patented knowledge.[60]

Voluntary patent licensing is a permissive mechanism for access to patented technologies.[61] Voluntary patent licenses allow sequential innovators to adopt the technologies and make improvements to them when the innovators are not in a position to exploit the commercial value of their innovations.[62] Unlike mandatory mechanisms, the scope of which have been judicially narrowed to protect property interests of patent owners, voluntary patent licensing has expanded significantly and has become arguably the most important means for sequential innovators to access

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[56] *See* Rebecca S. Eisenberg, *Patents and the Progress of Science: Exclusive Rights and Experimental Use*, 56 U. CHI. L. REV. 1017, 1060 (1989).
[57] *See* Roche Products, Inc. v. Bolar Pharm. Co., 733 F.2d 858, 862 (Fed. Cir. 1984). *See generally* Ronald D. Hantman, *Experimental Use as an Exception to Patent Infringement*, 67 J. PAT. OFF. SOC'Y. 617 (1985).
[58] *See* Whittemore v. Cutter, 29 F. Cas. 1120, 1121 (C.C.D. Mass. 1813).
[59] *See Roche Products, Inc.*, 733 F.2d at 862-63 (holding that the experimental use defense did not apply to a generic drug manufacturer who infringed a patent in conducting clinical tests for the purpose of gathering data necessary to obtain FDA drug approval).
[60] *See* Eisenberg, *supra* note 56 (arguing that the experimental use exemption to patent infringement liability, which allows subsequent researchers to enjoy free access to prior discoveries, promotes the progress of innovations).
[61] *See* Int'l Fed'n of Pharm. Mfrs. & Ass'ns, Voluntary Licenses and Non-Assert Declarations: Actions by R&D Pharmaceutical Companies That Facilitate Access to Medicines, (July 28, 2010), https://www.ifpma.org/resource-centre/voluntary-licenses-and-non-assert.
[62] *See* Suzanne Scotchmer, *Standing on The Shoulders of Giants: Cumulative Research and The Patent Law*, 5 J. ECON. PERSP. 29, 33 (1991) (arguing that patent licensing allows the information to flow from first generation innovators to second generation innovators).

prior innovations.[63] A recent empirical study by two economists, Bharat N. Anand and Tarun Khanna, found that patent licensing was one of the most common forms of inter-firm collaboration, accounting for about 25 percent of all inter-firm agreements, including joint ventures, R&D agreements, marketing agreements and etc, across several industry sectors.[64] Moreover, contrary to mandatory mechanisms, the contours of which are regulated by statutes or legal precedents, voluntary patent licensing is contingent on private negotiation. Because of the need for negotiation, patent licensing is subject to the peril of negotiation failure and transaction costs. In a study on costs of technology transfers, Professor Teece found that transaction costs of transferring technology accounts for on average 19 percent of the total cost of a licensee's project.[65]

[63] *See* Raymond T. Nimmer, *Breaking Barriers: The Relation Between Contract and Intellectual Property Law*, 13 BERKELEY TECH. L.J. 827, 830 (1998) (arguing that contracts, including patent licensing agreements, provide the means for the development and commercial exploitation of information assets).
[64] *See* Bharat N. Anand & Tarun Khanna, *The Structure of Licensing Contracts*, 48 J. INDUS. ECON. 103, 107 (2000).
[65] See David Teece, Technology Transfer by Multinational Firms: The Resource Cost of Transferring Technological Know-How, 87 Econ. J. 242, 247 (1977). *See also* FAROK J. CONTRACTOR, INTERNATIONAL TECHNOLOGY LICENSING: COMPENSATION, COSTS, AND NEGOTIATION 104-05 (1981) (showing that transaction costs averaged over $100,000 for licensing deals studied).

B. Patent Pools Promote Cumulative Innovation More Effectively

Patent licensing is the most common transaction in the patent marketplace and is pivotal to cumulative innovation. However, high transaction costs due to the inefficiencies in the patent marketplace burden sequential innovators in their efforts to access prior innovations.[66] This section outlines the reasons for high transaction costs of patent licensing in a patent marketplace and then explains how patent pool can reduce these costs.

1. Transaction Costs of Patent Licensing in a Patent Marketplace

Arrow, in his groundbreaking article "Economic Welfare and the Allocation of Resources for Invention," recognized that the patent marketplace plays an essential role in exchange of innovative information.[67] However, he also argued that failures in the marketplace have impeded cumulative innovation and caused the allocation of resources for innovation to be suboptimal.[68] He pointed out that the main culprit is high transaction costs of patent licensing.[69] Transaction costs are fundamentally different from licensing fees, as transaction costs are the cost of realizing the value of a potential transaction.[70] The higher transaction costs are, the less likely the transaction is to be made.[71] Legal scholars have previously focused on the effects of patent scope on cumulative innovation.[72] They have argued that suboptimal patent scope can be detrimental to sequential innovation. When the patent scope is too broad, first-generation innovators have strong bargaining

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[66] *See* Michael A. Heller & Rebecca S. Eisenberg, *Can Patents Deter Innovation? The Anticommons in Biomedical Research*, 280 SCIENCE 698, 700 (1998) (arguing that in the context of biomedical research, too many patent rights on basic research discoveries may stifle downstream research and product development by greatly increasing transaction costs).
[67] *See* Arrow, *supra* note 4, at 617 (arguing that patent law is essential for the appropriation of knowledge in the market place for ideas).
[68] *See* Kenneth Arrow, *Classificatory Notes on the Production and Transmission of Technological Knowledge*, 52 Amer. Econ. Rev. 29, 33 (1969) ("If one nation or class has the knowledge which enables it to achieve high productivity, why is not the other acquiring that information? . . . [T]he problem turns on the differential between costs of communication within and between classes.").
[69] *See id.* at 32-34 (arguing that the cost of communication is an essential factor influencing the diffusion of technology).
[70] *See* Richard A. Posner, *Transaction Costs and Antitrust Concerns in the Licensing of Intellectual Property*, 4 JOHN MARSHALL REV. OF INTELL. PROP. L. 325, 325 (2004) ("Transaction cost must not be confused with the license fee, or in other words the contract price").
[71] *Id.*
[72] *See* Merges & Nelson, *supra* note 7, at 884-908 (analyzing the impact of broad patent scope on the environment for subsequent development and improvement in various industries).

power to charge unreasonably high licensing fees from sequential innovators.[73] However, Coase's theorem suggests that with low transaction costs, the parties will bargain to a Pareto-efficient solution given any initial assignment of entitlements.[74] Therefore, it is high transaction costs of patent licensing, not the "size" of the rights — the patent scope —which is most crucial to cumulative innovation.[75]

a. Search Costs

Because voluntary patent licensing depends largely on private negotiations, a basic question for any transaction is who it is that one wishes to transact with.[76] If a family wants to buy a house, they will most likely turn to a respectable real estate agency that possesses comprehensive property listings. The aggregation of property listings in one place significantly reduces the search costs for transaction opportunities. In order to find issued patents and identities of patent owners, one may resort to patent databases for information. For example, the U.S. Patent and Trademark Office ("USPTO") maintains a searchable registry containing all issued patents and published applications.[77] However, the information one can obtain from a public registry is often incomplete and fragmented. First, patents often employ ambiguous titles and keywords, therefore increasing the difficulties of

[73] *See id.* at 844 (arguing that the scope of patents should be constrained, because "[i]n many industries the efficiency gains from the pioneer's ability to coordinate are likely to be outweighed by the loss of competition for improvements to the basic invention").
[74] *See generally* Ronald H. Coase, *The Problem of Social Cost*, 3 J. L. & ECON. 1 (1960). Harold Demsetz, *Toward a Theory of Property Rights*, 57 AM. ECON. REV. 347, 349 (1967).
[75] *See* Daniel F. Spulber, *Intellectual Contract and Intellectual Law*, (Northwestern Pub. L. Research Paper No. 18-16 Aug. 2018), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3192578 ("The problem of patent scope is similar to the problem of social cost. The social costs of an activity exceed the private costs to the owner of an activity when the activity imposes costs on others. These costs are a negative externality if the costs are not part of a transaction between the parties. Ronald Coase showed that private negotiation achieves efficiency when transaction costs are low, and few parties are involved.").
[76] *See* Carl J. Dahlman, *The Problem of Externality* 22 J. L. & ECON. 141, 147 (1979) ("In order to carry out a market transaction it is necessary to discover who it is that one wishes to deal with, to inform people that one wishes to deal and on what terms, to conduct negotiations leading up to a bargain, to draw up the contract, to under- take the inspection needed to make sure that the terms of the contract are being observed, and so on.") (quoting Coase, *supra* note 74).
[77] *See* Seven Step Strategy, U.S. PATENT & TRADEMARK OFFICE, http://www.uspto.gov/products/library/ptdl/services/step7.jsp (Oct. 28, 2016).

searching for relevant patents.[78] Second, new patents are applied or issued constantly. Therefore, search costs are not a one-time investment, but rather continuous investments. A public patent database that lags in updating patent information will drive up search costs.

b. Negotiation Costs

In many research areas, technological developments result in the issuance of numerous patents, each constituting an essential puzzle piece of a larger information base.[79] Therefore, cumulative innovation often requires licensing of a large set of patents. Such a phenomenon is called a "patent thicket," a term first coined by Professor Carl Shapiro.[80] He described a patent thicket as "an overlapping set of patent rights requiring that those seeking to commercialize new technology obtain licenses from multiple patentees."[81] The patent thicket phenomenon creates two sets of issues: the compounding effect of multiple licenses[82] and the holdup problem.[83] When sequential innovators must negotiate multiple patent licenses, they likely pay higher licensing fees, which raise their marginal cost of innovation.[84] Thus, a patent thicket creates barriers to cumulative innovation by forcing sequential innovators to pay higher licensing fees.[85]

Furthermore, the holdup problem creates another layer of difficulty for sequential innovators. The holdup problem can occur when a patent owner tries to exploit a sequential

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[78] *See* Peter S. Menell & Michael J. Meurer, *Notice Failure and Notice Externalities*, 5 J. LEGAL ANALYSIS 1, 8 (2013) (discussing the difficulty of navigating the patent database because of the ambiguous terms that a patent drafter will use).
[79] *See* Heller & Eisenberg, *supra* note 66, at 699 (arguing that the development of genomics results in numerous patents on gene fragments).
[80] *See generally* Carl Shapiro, *Navigating the Patent Thicket: Cross Licenses, Patent Pools, And Standard Setting*, 1 INNOVATION POL'Y AND THE ECON. 119 (Josh Lerner ed., 2001) (describing the patent thicket problem).
[81] *See id.* at 120.
[82] *See* Lemley & Shapiro, supra note 7, at 2010-17 (analyzing the problem of royalty stacking due to anticommons).
[83] *See generally* James Bessen, *Holdup and Licensing of Cumulative Innovations with Private Information*, 82 ECON. LETTERS 321 (2004) (arguing that when innovation is cumulative, early patentees can hold up later innovators).
[84] *See* Rosemarie Ham Ziedonis, *Don't Fence Me In: Fragmented Markets for Technology and the Patent Acquisition Strategies of Firms*, 50 MGMT. SCI. 804, 817–18 (2004) (illustrating empirical evidence of the compounding effects of multiple licenses); *see also* Michael Noel & Mark Schankerman, *Strategic Patenting and Software Innovation*, 61 J. OF INDUSTRIAL ECON. 481, 482 (2006).
[85] *See generally* Noel and Schankerman, *supra* note 84.

innovator's cost of pursuing second best alternative when the use of the patent is enjoined.[86] Suppose a licensor and a licensee are engaged in a Nash bargaining.[87] The licensor's minimum willingness to license is V. The licensee's maximum willingness to license is M. The Nash bargaining will lead to a negotiated price in the amount of (V+M)/2. Suppose a licensee has already incurred D research and bargaining costs *ex ante* negotiation and its second-best alternative is to abandon the research if a license to the patent is not granted. In this case, the licensee's maximum willingness to license is increased to M+D. As a result, the negotiated price will be (V+M+D)/2. The simple calculation shows that because of the sunk cost, a licensee is willing to pay more, although the value of the underlying patent stays the same. The sunk cost indirectly increases the bargaining power of a patent owner and allows it to capture a share of the sunk cost proportional to its bargaining skills.[88] In essence, the patent thicket problem increases the transaction costs of licensing and hinders access to patented knowledge.

[86] *See* Lemley & Shapiro, *supra* note 7, at 2000-02 (arguing that if a product design feature violates a patent, a patent holder can extract royalties that exceed the reasonable royalty rate by holding up the product maker for a share of the costs it would take to redesign the product if use of the patent were enjoined).
[87] *See id.* at 1995-98. (discussing Nash bargaining problem).
[88] *See* Joseph Farrell, John Hayes, Carl Shapiro & Theresa Sullivan, *Standard Setting, Patents, and Hold-up*, 74 ANTITRUST L. J., 603, 613 (2007) (arguing that a patent holder can capture a share, proportional to its bargaining skill, of sunk investments by a licensee by holding-up).

2. Patent Pools Improve Access by Reducing Transaction Costs

Game theorists suggest that parties who are engaged in repeated transactions learn to develop strategies and take actions which allow utility-enhancing transactions to occur.[89] For example, Robert Ellickson has argued that informal (i.e., non-legal) behavioral norms can emerge out of repeated interactions among members of close-knit communities.[90] A patent pool is one of the institutions that emerged from repeated transactions between patent owners and licensees.[91] Patent pools contribute to cumulative innovation by reducing the transaction costs of patent licensing in the following three aspects.

First, a patent pool can serve as an information center for sequential innovators. As disused in Section II (B)(1)(a), search costs comprise a large fraction of transaction costs in patent licensing.[92] As opposed to conducting a search on a patent registry, which is often ineffective, a sequential innovator can easily find comprehensive information about patents in a specific technology field through a patent pool. For example, MPEG Licensing Association controls many patent pools in various industrial standards.[93] For each patent pool, it not only publishes a comprehensive list of included patents and identities of their owners,[94] but also provides detailed references on how each patent is related to the underlying technology.[95]

Second, patent pools solve the patent thicket problem by aggregating numerous patents in a single entity. The recently developed "anticommons" theory by Michael Heller highlighted the utility

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[89] *See generally* MARTIN J. OSBORNE, AN INTRODUCTION TO GAME THEORY (2004) (discussing the ideas behind game theory).
[90] *See* ROBERT C. ELLICKSON, ORDER WITHOUT LAW: HOW NEIGHBORS SETTLE DISPUTES 164-66 (1991).
[91] *See* Robert P. Merges, *Contracting into Liability Rules: Intellectual Property Rights and Collective Rights Organizations*, 84 CAL. L. REV. 1293, 1302 (1996) ("The high costs of contracting-both among members and between members and users-drive the right holders to pool their property rights in a collective organization.").
[92] *See supra*, section II (B)(1)(a) and accompanying notes 76-78.
[93] *See About*, MPEG LA, http://www.mpegla.com/main/Pages/About.aspx (last visited Oct. 31, 2018).
[94] For one example, see MPEG-2 Systems Patent List. *MPEG-2 Systems Attachment 1*, MPEG LA (Oct. 1, 2018) http://www.mpegla.com/main/programs/M2/Documents/m2-att1.pdf.
[95] *See* MPEG-2 PATENT PORTFOLIO LICENSE ILLUSTRATIVE CROSS-REFERENCE CHART, http://www.mpegla.com/main/programs/m2/Documents/m2CrossRefChart.pdf (last visited Sept. 29, 2018).

of bundling property rights.[96] The gist of his theory is that when too many property rights of small scales are granted, it is very burdensome to utilize these rights because of the compounding effects of negotiating multiple licenses.[97] As a result, these rights are not efficiently used.[98] In the case of patents, the "anticommons" phenomenon means that sequential innovators cannot efficiently use prior patented innovations because of high transaction costs. A patent pool represents a natural solution to the problem.[99] Under a patent pool, an entire group of patents is licensed in a package, either by one of the patent holders or by a joint licensing agent.[100] Therefore, sequential innovators interested in a certain technology covered by a patent pool can, in one stop, license all the patents essential to that technology.[101]

Third, a patent pool prevents holdup by centralizing licensing negotiations. As discussed in Section II (B)(1)(b), if a patent owner knows that it owns the last patent a party needs to license, it can demand a substantially higher royalty because of the sunk cost of previous negotiations.[102] Patent pools address this holdup problem by providing a means in which most, if not all, necessary licenses are obtained at one time in a package.

III. DESIGNING PATENT POOLS

A patent pool can function as a collective knowledge space of prior innovations for sequential innovators. Because a patent pool operates similarly to a commons, institutional

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[96] Michael Heller, *The Tragedy of Anticommons: Property in the Transition from Marx to Markets*, 111 HARV. L. REV. 622, 640 (1998) ("[C]reating private property requires moving from too many owners, each exercising a right of exclusion, to a sole decisionmaker [sic], controlling a bundle of rights.").
[97] *See id.* at 641-42.
[98] *See id.* at 687-88 ("Anticommons property is prone to the tragedy of underuse. Once anticommons property appears, neither markets nor subsequent regulation will reliably convert it into useful private property, even if the property rights are "clearly defined" and contracts are subject to the "rule of law." Transaction costs, holdouts, and rent-seeking may prevent economically justified conversion from taking place.").
[99] *See* Heller & Eisenberg, *supra* note 66, at 700 (noting that "in the automobile, aircraft manufacturing, and synthetic rubber industries, patent pools have emerged, sometimes with the help of government, when licenses under multiple patent rights have been necessary to develop important new products").
[100] Shapiro, *supra* note 80, at 127.
[101] Merges, *supra* note 4, at 17.
[102] *See* Lemley & Shapiro, *supra* note 7.

economists have used the term innovation commons to characterize patent pools.[103] Institutional theories suggest that patent pools are likely to suffer typical problems associated with common pool resources ("CPR"), such as over-consumption, underinvestment, or freeriding.[104] This section will explain how the collective action theory can help to understand the challenges facing patent pools and will apply the collective action theory to several patent pool design issues.

A. The Collective Action Theory

Broadly speaking, collective action is a mode of economic governance.[105] Economist Andreas Papandreou classified the property rights regime as a decentralized governance structure, state regulation as the most centralized structure and collection action being in the middle.[106] The following is a spectrum of economic governance.

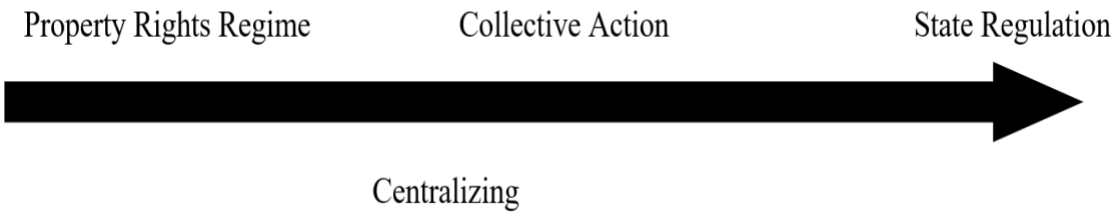

Figure 3: A Spectrum of Economic Governance

[103] *See* Jason Potts, *The Innovation Commons* (April 21, 2012) *available* at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2706856 (comparing patent pools to innovation commons).
[104] *See* ELINOR OSTROM, GOVERNING THE COMMONS: THE EVOLUTION OF INSTITUTIONS FOR COLLECTIVE ACTION, POLITICAL ECONOMY OF INSTITUTIONS AND DECISIONS, 3-5 (1990) (using the prisoner's dilemma game to illustrate the tragedy of commons).
[105] *See* Oliver E. Williamson, *The Economics of Governance*, 95 AM. ECON. REV. 1, 1 (2005) ("The economics of governance is an effort to implement the 'study of good order and workable arrangements,' where good order includes both spontaneous order in the market, which is a venerated tradition in economics and intentional order, of a 'conscious, deliberate, purposeful' kind.").
[106] *See* ANDREAS A. PAPANDREOU, EXTERNALITY AND INSTITUTIONS 195-227(1994) (suggesting a continuum of governance structures, ranging from property rights to formal institutions); OSTROM, *supra* note 104, at 14 ("Institutions are rarely either private or public – 'the market' or 'the state.' Many successful CPR institutions are rich mixtures of 'private-like' and 'public-like' institutions defying classification in a sterile dichotomy."). *See generally* Robert Wade, *The Management Of Common Property Resources: Collective Action As An Alternative To Privatization Or State Regulation*, 11 CAMBRIDGE J. ECON. 95 (1987) (arguing collective action as an alternative to privatization or state regulation).

The collective action theory concerns the causes and solutions for the divergence between group interests and self-interests in a multi-party collaborative environment.[107] The core of the theory is that self-interested individuals with common interests will not necessarily attempt to further those common objectives.[108] Economist Mancur Olson, stated:

> If the members of a large group rationally seek to maximize their personal welfare, they will *not* act to advance their common or group objectives unless there is coercion to force them to do so, or unless some separate incentive, distinct from the achievement of the common or group interest is offered to the members of the group individually on the condition that they help bear the costs or burdens involved in the achievement of the group objective.[109]

When it comes to cumulative innovation, the expansion of easily-accessible knowledge space of innovation is a common interest. The larger that knowledge space is, the easier it is for sequential innovators to conduct cumulative innovations. However, innovators' self-interests may disincentivize them from contributing to this knowledge space.[110] For example, a patent owner may choose to hold up in licensing so that it can take advantage of a licensees' ruined research and bargaining costs.[111]

1. Appropriation and Provision Rules

Collective action theorists have studied rules intended to prevent the breakdown of cooperative governance, including rules on who can join a group, how rights to resources are determined, how compliance is monitored, and what sanctions are imposed.[112] Overall, the collective action theory identifies two essential issues: appropriation and provision.[113] Appropriation concerns the effects of various methods of allocating a fixed quantity of resource units to the appropriators

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[107] *See* OSTROM, *supra* note 104, at 5.
[108] *See id.* at 6.
[109] MANCUR OLSON, THE LOGIC OF COLLECTIVE ACTION: PUBLIC GOODS AND THE THEORY OF GROUPS 2 (1965).
[110] Ostrom, *supra* note 104 at 6.
[111] *See supra* section II(B)(1)(b) and accompanying notes.
[112] *See* OSTROM, *supra* note 104, at 9 (outlining the scope of inquiry for collective action theorists).
[113] *See* ELINOR OSTROM, ROY GARDNER & JAMES WALKER, RULES, GAMES, AND COMMON POOL RESOURCES, 8 (1994).

who are interdependent.[114] Any agreed-on appropriation rules are impacted by a potential breach. Therefore, monitoring the compliance with the rules and punishing non-compliance are also essential.[115] Provision concerns the impact of various methods of assigning obligations for building, restoring, or upgrading the resource system over time.[116] Because the external environment of a CPR is often subject to unexpected change, it is important for members of a CPR to adopt contingent appropriation and provision strategies to minimize incentives for opportunistic behavior.[117]

For example, take a common pasture used by multiple herders to illustrate how appropriation and provision rules interact.[118] Because an unmanaged common pasture is very likely to be depleted due to herders' incentives to overuse, it is necessary to design a set of appropriation rules that allocate grasses as resource units to herders. A potential rule can be that herders rotate to graze their cattle on the pasture exclusively for a certain period. Furthermore, the appropriation rules must consider the effects of uncertainties on the distribution of resource units. It is plausible that an unexpected drought will affect some herders and spare others. An inflexible appropriation rule, which does not take into account the unexpected drought, is likely to sow distrust among herders. A quick solution is that unaffected herders are obligated to compensate the affected ones, which effectively spreads the risks among all the herders. The drawback of this solution is that, although it would foster risk sharing and mutual trust, it could disincentivize members from taking precautions

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[114] *See* Ostrom, *supra* note 104, at 47 ("When appropriators face appropriation problems, they are concerned with the effects that various methods of allocating a fixed, or time-independent, quantity of resource units will have on the net return obtained by the appropriators.").

[115] *See id.* at 186-87. "If occasional rule infractions are not discovered, the rule-breaker is even better off in the short run. However, if one were to break the rules several times without discovery, one might revise one's estimate of the efficacy of the current monitoring system in deterring others from similar infractions. That would lead an occasional rule-breaker to adopt a higher rate of rule-breaking behavior. Obviously, as undetected rule infractions become more frequent and CPR conditions become worse, the higher will be the probability that other individuals will increase their rates of rule-breaking behavior . . . Thus, monitoring and graduated sanctions are necessary to keep the rate of rule-following high enough to avoid triggering a process in which higher rates of rule infractions fuel subsequent increases in rates of rule infractions." *Id.*

[116] *Id.* at 47.

[117] *See id.* at 36 ("Because CPR settings extend over time, and individuals adopt internal norms, it is possible for individuals to utilize contingent strategies, not simply independent strategies, in relating to one another. By 'contingent strategies' I mean a whole class of planned actions that are contingent on conditions in the world.").

[118] *See also id.* at 61-65 (discussing the communal tenure of Torbel, Switzerland).

for unexpected weather conditions. Therefore, a sensible contingent strategy is to add a complementary rule that requires adversely-affected herders to take reasonable precautions to mitigate potential losses. In terms of the provision for a common pasture, one can argue that as long as the appropriation rate is below the upper limit of the natural sustained growth of grass, herders do not need a provision regime. However, in many instances, continued usage and unexpected natural disasters will require an active response from the appropriators to maintain the commons. Therefore, herders may have to agree on the distribution of the responsibilities and costs of building an irrigation system to offset potential droughts.

B. Designs of Patent Pools to Promote Cumulative Innovation

This subsection will analyze how the collective action theory can inform about patent pool designs. This subsection will focus on two main design issues: (1) appropriation and (2) provision.

1. Appropriation

For a patent pool, the appropriation rules concern how the patented knowledge can be licensed and utilized by patent pool members and third parties. There is one important distinction between patent pools and traditional CPRs — the resource units of a patent pool are non-rivalrous.[119] Appropriation limitations are generally essential to the long-term sustainability of CPRs with rivalrous goods, such as common fisheries.[120] After all, without such restriction, overuse will occur. However, the non-rivalrous nature of patents means that unlimited use will not result in

[119] *See* Herbert Hovenkamp, *Competition for Innovation*, 2012 COLUM. BUS. L. REV. 799, 819 (2012) ("[P]atents are non-rivalrous, which means that one person's "consumption" of a patent via licensing does not reduce the amount that is left over for others.").

[120] *See* Herbert Hovenkamp, *Antitrust and the Movement of Technology*, 19 GEO. MASON L. REV. 1119, 1131 (2012) ("Commons for rivalrous goods such as grazing rights or fisheries could not survive without limiting output. The classical 'tragedy' of the commons is that when participants do not bear the full cost of their use, they will use too much because excessive use without maintenance reduces their own short-run costs."); *see also* Garrett Hardin, *Tragedy of the Commons*, 162 SCIENCE 1243, 1244 (1968).

depletion of patent pools.[121] Therefore, for a patent pool to disseminate innovative technologies to sequential innovators and facilitate cumulative innovations, there does not need to be a restriction on appropriation of patents in patent pools.

2. Provision

a. Inducing Patent Owners to Join Patent Pools

A patent pool, unlike a natural CPR, does not exist naturally, but must be created. Thus, the provision for patent pools includes inducing patent owners to join a patent pool in the first place. For a natural CPR, an addition of a member could bring about negative consequences because it makes the appropriation more fragmented and more difficult to manage. However, for a patent pool, an addition of a new member will likely increase the overall value of a patent pool because it signals that the patented knowledge in the pool is useful. In other words, a patent pool displays positive network effects.[122]

Because joining a patent pool is voluntary, a rational patent owner will weigh the benefits and costs of doing so.[123] The benefits include the sharing of licensing revenue and the saving of transaction costs in licensing.[124] Case studies have shown that patent pools have generally used three main mechanisms to allocate licensing revenue: (1) royalty-free rules, (2) numeric proportional rules, where members receive a share of the aggregate earnings based on the number of patents they contribute to the pool, and (3) value proportional rules, where members with more valuable

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[121] *See* Hovenkamp, *supra* note 120, at 1125 ("[T]he patent pool has no close equivalent of overfishing on the supply side, because the supply is infinite.").

[122] *See* Eric Jorgenson, *The Power of Network Effects: Why They Make Such Valuable Companies, and How to Harness Them*, MEDIUM, EVERGREEN BUSINESS WEEKLY, (June 22, 2015) https://medium.com/evergreen-business-weekly/the-power-of-network-effects-why-they-make-such-valuable-companies-and-how-to-harness-them-5d3fbc3659f8 ("A product displays positive network effects when more usage of the product by any user increases the product's value for other users . . . .").

[123] *See generally* Reiko Aoki & Sadao Nagaoka, *The Consortium Standard and Patent Pools, in* INSTITUTE OF ECONOMIC RESEARCH, HI-STAT DISCUSSION PAPER SERIES, (Working Paper No. 32 May 2004), https://www.immagic.com/eLibrary/ARCHIVES/GENERAL/HIT_U_JP/H040500R.pdf.

[124] *See* Anne Layne-Farrar & Josh Lerner, *To Join or Not to Join: Examining Patent Pool Participation and Rent Sharing Rules*, 29 INT'L. J. OF IND. ORG. 294, 296 (2011) (arguing that patent pool members benefit from pool participation in two main ways: (1) earning patent royalties and (2) saving transaction costs of licensing).

contributions receive a larger share of the earnings.[125] Royalty-free rules will most likely result in lower rates of participation than either other allocation rules because they do not compensate for patent owners' prior innovative efforts.[126] MPEG-LA used a typical numeric proportional rule for its MPEG-2 patent pool.[127] The rules stated that royalty payments would be divided according to the formula (P/N)*M, where P is the number of pool patents a party holds in a country, N is the total number of essential patents in that country belonging to the pool, and M is the total royalties collected in that country.[128] Although numeric proportional rules are relatively easy to administer, they do not consider the underlying value of each patent and tend to disincentivize pool members from over-patenting.[129] Moreover, empirical studies have shown that the distribution of patent value is highly skewed in a patent pool, where some patents are worth a considerable amount, while others are worth little.[130] Although value proportional rules are more complex to administer than either of the other two rules, they create a more equitable division of licensing revenue, which can encourage pool participation. In addition, to bridge the potential disagreements about patent valuation, it is advisable for patent pools to delegate patent evaluation to an independent examiner.[131] An independent examiner can prevent self-serving valuation and discourage members from placing dubious patents into the pool in order to receive a larger share of licensing revenue.[132]

The saving of transaction costs is another important incentive to join a patent pool.[133] For a patent owner, transaction costs include cost of negotiating patent licenses and enforcing exclusive

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125 *Id.*
126 *Id.* at 296-97.
127 *Id.* at 296.
128 *Id.*
129 *See* Layne-Farrar & Lerner, *supra* note 124, at 296 ("The prevalence of such numeric rules is somewhat surprising, since it is well understood that simple patent counts do not reflect the value of underlying technical contributions.").
130 *See* F.M. Scherer & Dietmar Harhoff, *Technology Policy for A World of Skew Distributed Outcomes*, 29 RES. POL'Y. 559, 559 (2000).
131 *See* Layne-Farrar & Lerner, *supra* note 124, at 295-96.
132 *Id.*
133 *Id.* at 296.

rights.[134] To lower the negotiation costs, a patent pool can hire a joint licensing agent and offer relatively uniform licensing terms with potential licensees.[135] To reduce the enforcement costs, a patent pool can rely on collective enforcement rather than individual enforcement. The theory of collective enforcement of property rights can be traced back to Barry C. Field's work.[136] In Field's study, a community had to decide the optimal size of parcels for each member of a community to administer.[137] A finer division means more borders.[138] The more borders, the harder it is to patrol against trespassers.[139] He concluded that when enforcement costs are considered, efficiency is not necessarily served by small parcel sizes.[140] He further concluded that enforcement efficiency can motivate individuals to cede some property rights to a community.[141] Therefore, a collective enforcement mechanism within a patent pool can increase overall enforcement efficiency and then will incentivize patent owners to join a pool.

[134] Paul G. Heald, *Transaction Costs and Patent Reform*, 23 SANTA CLARA COMPUTER & HIGH TECH L. J. 447, 448 (2012).
[135] *See* Merges, *supra* note 4, at 14 ("The relatively uniform terms offered by this organization then lower the costs of exchange with users.").
[136] *See* Barry C. Field, *The Evolution of Property Rights*, 42 KYKLOS 319 (1989).
[137] *Id.* at 322.
[138] *See* Merges, *supra* note 91, at 1325 (explaining Field's study).
[139] *Id.*
[140] *Id.*
[141] *Id.*

b. Upgrading Patent Pools

Peter Suber, one of the most well-known pioneers in the open access movement, in his article *Creating an Intellectual Commons Through Open Access,* warned that intellectual commons, unlike natural CPRs, face the risk of being obsolescent.[142] He described such a phenomenon as "a tragic stalemate."[143] A tragic stalemate is different from the classic tragedy of the commons because it results not in the depletion of a CPR, but a stalemate in the growth of a CPR.[144] As new technologies and innovations emerge, a patent pool can become outdated if patents on new innovations are not continuously added to the pool. A potential solution to the tragic stalemate facing a patent pool is a grant-back provision in patent licenses that contractually obligates licensees to place patents on the new innovations back into the pool.[145] How a grant-back provision can solve the tragic stalemate is illustrated with a simple prisoner's dilemma game.[146] Suppose there are two members who both have a royalty-free license to patents in a pool. Each member has two options: placing new patents in the pool or not placing new patents in the pool. If neither member places new patents in the pool, neither member has access to the other party's innovation and each member obtains eight units of profits. If each member chooses to contribute new patents to the pool, each member is better off with ten units of profits because either member can access the other party's innovation for free. If member A places its new patents in the pool while member B does not, member B will have access to member A's innovation and at the same time keep its own innovation confidential. Therefore, member B will see its payoff improved to eleven units of profits. On the contrary, member A will see its payoff drop to seven units of profits because it forgoes the

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[142] *See* Peter Suber, *Creating an Intellectual Commons Through Open Access*, *in* UNDERSTANDING KNOWLEDGE AS A COMMONS: FROM THEORY TO PRACTICE 183 (MIT Press 2007) (emphasizing the need for distinguishing tragic depletions, which is the classic tragedy of the commons, from the problem of tragic stalemates).
[143] *Id.*
[144] *See id.* at 184 ("The result is not the destruction of a common good, but a paralysis that prevents otherwise motivated players from creating a common good.").
[145] *See* Layne-Farrar & Lerner, *supra* note 124, at 296.
[146] *See* Ostrom, *supra* note 104 (discussing the prisoner's dilemma game).

opportunity to seek compensation for its innovative efforts and does not receive access to member B's innovations in return. The following payoff matrix illustrates the prisoner's dilemma game.

		Member A	
		In the Pool	Not in the Pool
Member B	In the pool	10 10	11 7
	Not in the Pool	7 11	8 8

Figure 4: A Prisoner's Dilemma Game

The Nash equilibrium of the game is that both members will choose not to place new patents in the pool.[147] A strategy that will lead to a Pareto-improving outcome is to have both members contribute patents on new innovations to the pool. One viable means to achieve the more efficient equilibrium is to use some coercive power to punish undesirable actions. For example, a grant-back provision can stipulate that if a member does not place new patents in the pool, it must relinquish the royalty-free license to all the patents in the pool. Because the provision effectively reduces the payoff of not placing the patents in the pool, members are inclined to contribute new patents to the pool. In essence, a grant-back provision becomes an important mechanism for a patent pool to upgrade itself based on new technological developments. For example, there was a grant-back provision in MPEG-2 licensing agreements.[148] Licensees of MPEG-2 patent portfolio

[147] S.K., *What is the Nash Equilibrium and Why Does it Matter?*, THE ECONOMIST (Sept. 7, 2016) https://www.economist.com/the-economist-explains/2016/09/06/what-is-the-nash-equilibrium-and-why-does-it-matter.

[148] *See* MPEG-LA, MPEG-2 License Agreement, MPEG-2 Patent Portfolio License, cl. 7.3.

were given two options under the agreement.[149] One option was to grant the patent pool—MPEG Licensing Association—a worldwide non-exclusive license to their future patents essential to the MPEG-2 standard.[150] The other option was to agree to grant a worldwide, non-exclusive license to any sublicensees of the patent pool to future patents essential to the MPEG-2 standard.[151]

IV. CONCLUSION

In this article, I analyzed a patent pool's function to promote cumulative innovation. I identified two institutional conditions for cumulative innovation: disclosure and access. Since the patent marketplace is an important venue for exchanges of innovative ideas, it is imperative to understand how these two conditions are manifested. My analysis concludes that access to patented knowledge in the patent marketplace is often hindered because of high transaction costs of patent licensing. I argued that a different type of institutions for innovation—the patent pool— can better promote cumulative innovation than the traditional patent marketplace. A patent pool creates an easily-accessible knowledge space of prior innovations. In that space, transaction costs of patent licensing are lowered because patent pools provide detailed information about patents related to specific technologies, aggregate patents and centralize licensing negotiations.

In the last part of the article, I discussed issues related to patent pool designs. Because creating a patent pool as a common knowledge space requires collaboration among patent owners, the success of a patent pool often depends on whether patent owners can overcome collaborative failure. I introduced the collective action theory as the analytical framework for patent pool design. By focusing on two design issues, appropriation and provision, I made three design suggestions to reduce a patent pool's cooperative failure: (1) appropriation limitation is not necessary for the long-term sustainability of a patent pool; (2) in order to induce patent owners to join a patent pool, a

[149] *Id.*
[150] *Id.*
[151] *Id.*

patent pool should establish mechanisms that fairly allocate licensing revenue and reduce transaction costs of licensing; and (3) grant-back provisions are desirable to prevent a patent pool from becoming obsolescent. Although these suggestions are by no means comprehensive, they can further our understanding on how to create a common knowledge space within the patent marketplace.