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Knowledge Commons (2016)

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Knowledge Commons

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I. Introduction

Knowledge commons refers to an institutional approach (commons) to governing the production, use, management, and/or preservation of a particular type of resource (knowledge).

Commons refers to a form of community management or governance. It applies to a resource, and it involves a group or community of people who share access to and/or use of the resource. “The basic characteristic that distinguishes commons from noncommons is institutionalized sharing of resources among members of a community” (Madison et al., 2010, p. 841). Commons does not denote the resource, the community, a place, or a thing. *Commons* is the institutional arrangement of these elements and their coordination via combinations of law and other formal rules; social norms, customs, and informal discipline; and technological and other material constraints. Community or collective self-governance of the resource, by individuals who collaborate or coordinate among themselves effectively, is a key feature of commons as an institution, but self-governance may be and often is linked to other formal and informal governance mechanisms. More detail is supplied below.

For purposes of this chapter, *knowledge* refers to a broad set of intellectual and cultural resources. There are important differences between various resources captured by such a broad definition. For example, knowledge, information, and data may be different from each other in meaningful ways. But an inclusive term is necessary in order to permit knowledge commons researchers to capture and study a broad and inclusive range of commons institutions and to highlight the

importance of examining knowledge commons governance as part of dynamic, ecological contexts (see Benkler, 2013 and Cohen, 2006 on the importance of understanding the cultural environments in which knowledge resources are produced and used). Prior attempts to use “cultural environment” were cumbersome (for further explanation, see Frischmann et al., 2014; Frischmann, 2013a and Bertacchini et al., 2012). For similar reasons related to inclusiveness, potentially narrower definitions of knowledge goods are avoided; in addressing resources, this chapter does not limit its discussion to precise distinctions among private goods, public goods, club goods, and/or toll goods. The resource set includes information, science, knowledge, creative works, data, and other related resources.

Knowledge commons thus refers to the institutionalized community governance of the sharing and, in some cases, creation, of a wide range of intellectual and cultural resources. This chapter provides an overview of efforts to develop and apply a research framework to investigate knowledge commons on a systematic basis, across a diverse range of contemporary and historical cases and across cases that are both supported by modern information technologies and those that pre-date or that operate independently of those technologies.

II. Theoretical background

The problem of providing empirical justifications for intellectual property (IP) law regimes (patent and copyright in particular) has vexed modern researchers for at least 50 years (Machlup, 1958). Intellectual property goods such as patentable inventions and copyrighted works are conventionally modeled as public goods, which are neither excludable nor depletable, in contrast to private goods, which are both. That pattern leads to the framing of the following social dilemma: It is typically assumed by researchers that likely overconsumption of intellectual property goods by uncoordinated, self-interested consumers and users in some “common” domain will lead to diminishment of the incentive to invest in their production, because the inventors and creators of those goods will be discouraged by their inability to recover necessary investments in and returns on innovation. In short, free riders among consumers will produce an intellectual property version of what Hardin referred to as a tragedy of the commons (Landes and Posner, 2003; Hardin, 1968). Such a tragedy may be solved, if at all, by the creation and assignment of marketable property rights to individual owners of specific resources within what was formerly held “in common,” or by production and governance of the resource by a single, central authority, such as the state.

The theoretical assumptions behind the conventional tragedy of the commons model have long been belied by the fact that knowledge-generating and innovation-generating institutions based on successful coordination and collaboration among knowledge producers and users have existed for decades – even centuries, often despite the absence of intellectual property rights owned by individual creators or inventors. Perhaps the best example of this phenomenon is the modern research university, whose historical antecedents can be traced back roughly 1,000 years (Madison et al., 2009). Universities have long served as knowledge-generating and knowledge-sustaining institutions despite faculty researchers often exercising few conventional market-based IP interests. Openly accessible knowledge resources do not necessarily pose the dilemmas of “tragic” outcomes; social dilemmas involving knowledge need not be solved by the delineation of private rights exchanged in markets, or left to strong coordination by the state.

Contemporary technological developments grounded in patterns of Internet exchange, such as open source computer programs and Wikipedia, have renewed interest in and have prompted relatively recent re-examinations of the conventional tragedy of the commons model along several different dimensions. Each of these highlights a different respect in which the so-called “tragic commons” may not develop around a shared resource and in which community self-governance has the potential to develop as an institution to the point that sustained innovation is the probable result, rather than an overconsumed and/or underproduced resource. Some of these also highlight certain respects in which the term “commons” may give rise to ambiguity, at least in theoretical terms.

The public domain: Free and unhindered user access to certain knowledge and information resources, particularly basic ideas and facts (truths) about the world, is treated as a critical element of intellectual property and information law and policy by scholars including Boyle (2003, 2008), Lessig (2001), Litman (1990), and Lange (1981). These authors stress the cumulative character of knowledge and information production and the proposition that new knowledge is not possible without elements of free access to existing knowledge as “building blocks” (Boyle, 2008, p. 41) of new works and inventions. In this framework, the term “commons” denotes common or shared resources that are used by many users (and perhaps, potentially, by all of them) without fees and also without legal or contractual restrictions. Governance of public domain resources by self-organized communities or collectives is not necessarily inconsistent with their public or common status, but scholars stress their open nature over the institutional frameworks by which new creations or innovations emerge from them. The licensing entity known as “Creative Commons” is grounded on this view, where “Creative Commons” licenses of different forms are designed to enable users of

copyrighted works intentionally to facilitate later uses of their works either by specifying “open” licensing terms or by dedicating their works to the public domain.

Commons-based peer production: Beginning with the emergence of large-scale implementation of open source computer programs and the initial stabilization of the Internet encyclopedia Wikipedia, Benkler (2006, 2013) theorizes that sustainable innovation processes could emerge and exist without support from formal intellectual property regimes, or with limited support. Drawing in part on Boyle’s conception of the commons as a domain of information accessible to any and all, Benkler identifies certain cases where independent actors produce sustainable innovations by operating in coordination but without a traditional market, hierarchy, or firm (thus, “peers”). Benkler’s examples focus mostly on Internet-enabled innovations such as open source computer programs, but his concept extends explicitly to certain “peer” produced innovations beyond the technology arena. Among them is the practice of “casual carpooling” in the San Francisco area and “slugging” in the Washington, DC area, in which commuting drivers offer spare seats in their cars to anonymous volunteer riders, forming carpools that can operate legally in carpool-only lanes on highways and bridges (Benkler, 2004).

Semicommons: Looking to classic or traditional models of property law theory modeled on rights in land, Smith (2000) posits the existence of a model of property rights that exists in between full rights of exclusion and full openness. Looking primarily to medieval English practice, he identifies land-holding patterns that operated on what he refers to as a successful semicommons model, in which common and private uses of property co-exist. By this he means that open fields at times are subject to collective or communal governance regarding their use (for grazing) but are interspersed with scattered strips of land, subject to rights of exclusion, for grain growing. Heverly (2003) and Smith (2005) extend the model toward certain domains of information rights, notably telecommunications law and policy (see also Weiser and Hatfield, 2005). The implications of the model are debated. Bertacchini, De Mot, and Depoorter (2009) theorize that semicommons create opportunities for strategic behavior and the fragmentation of property claims, introducing costs that outweigh the possible benefits of the regime. David (2003) argues that some combination of open and closed access to a property resource is overwhelmingly likely to be more socially efficient than completely one or the other.

Infrastructure: Scholars have asked whether certain types or classes of innovation are more or less susceptible to tragedies of the commons, as a matter

of theory. Frischmann (2013b) argues that creating and allocating marketable property rights to individual rights owners is unlikely to lead to the production of sustainable innovation with respect to the class of infrastructure resources. The reason is that the anticipated social welfare benefits associated with the use of infrastructure is likely to accrue to actors other than those who invest in infrastructure; infrastructure users are likely to be heterogeneous and distributed across space and time; and the character of their demand for the resources is likely to be highly variable (see also Frischmann and Lemley, 2007). The resource is likely to be a shared input into a diverse range of outputs. In that event, the market is unlikely to aggregate this social demand in a way that may be concentrated productively in marketable innovation goods. Rose (1986) foreshadowed Frischmann in part by highlighting the presence of forms of shared or common rights of access to and ownership of property in ancient Roman law, particularly with respect to transportation resources, such as roads. She refers to her description as a “comedy of the commons.”

IP without IP (sometimes referred to as “IP’s negative space”): In recent years intellectual property and innovation scholars have produced a number of case studies of specific communities that operate successfully as producers of innovative and creative works but without relying formally on intellectual property interests. These are domains where IP might regulate production, but for one reason or another, it does not. The cases are collected loosely under the heading “Intellectual Production [IP, for this purpose] Without Intellectual Property [IP]” (Perzanowski and Darling, 2017). These researchers ask: what motivates the production of new works or inventions (that is, how is the tragedy of the commons overcome), if formal intellectual property law is not supplying the relevant incentive? This collection of “IP without IP” cases does not rely on a standard research framework or on a stated concept of commons or “the commons,” but it does investigate and build on the insight that community or collective self-governance can provide a powerful mechanism for creative production. In some instances, work produced by members of these communities is not eligible for intellectual property protection (Raustiala and Sprigman, 2006 (discussing the fashion industry in the United States)); in some instances, it is eligible for such protection but members of the group choose to rely on social norms that operate as substitutes for formal intellectual property interests (Perzanowski, 2013 (discussing tattoo artists)). In some instances members of the group opt out of any system that resembles intellectual property norms or formal interests and substitutes their own community-based governance system (Fagundes, 2012) (discussing roller derby competitors). Related work explores the motivations of creative and inventive individuals and their partners, supporters, and collaborators, at times in individual

context (Silbey, 2014); at times in institutional context (Murray et al., 2014; De Beer et al., 2014).

Open innovation: Management scholars have identified a class of research and development and innovation practices that are collected under the heading “open innovation” (Chesbrough, 2003). In “open innovation” systems, traditional or conventional hierarchical firms manage their research and development functions in part by organizing confederations of independent or semi-independent researcher/contributors, whose work is often shared with each other and facilitated and coordinated via technology platforms developed and maintained by the principal firm. “Open innovation” therefore describes less a single model of innovation by coordination of third-parties and more a family of similar management practices. The research problems are typically drawn from relatively early challenges in the development of a product, service, or technology and are typically susceptible to being broken up or distributed to multiple researchers at once. Their respective contributions may be treated as competitive with each other, or as complementary. The researchers may be more or less independent from each other as well as from the principal firm, in terms of contractual relationships, in terms of geographic location, and in terms of knowledge and awareness of the others’ work. The problems being solved may be given to the researchers in the context of a tight management relationship that appears more or less analogous to the organization of a traditional firm, or may be much more loosely specified.

User Innovation: A different group of management scholars has identified a class of innovation practices that focus on the type of innovator rather than on the organizational design of the innovation institution. In these cases, clustered under the heading “user innovation” (von Hippel, 2005), groups of users or consumers of a product or technology experiment or innovate with their own copies or instances of the thing in order to adapt it to their own needs, goals, or other circumstances. Researchers have identified a typical pattern, by which purely local innovations of this sort are communicated and shared among users; often a lead user or entrepreneurial user advances a shared version of the innovated good and in the end a new, improved device is marketed. While the process of user innovation is far from seamless or even frequent, it is observed across a broad range of markets and technologies, both in contemporary practice and through history. Successful user innovation exists as a documented practice in certain innovation communities (Bogers et al., 2010).

New Commons: Ostrom, who pioneered investigation of commons governance with respect to shared natural resources, together with certain colleagues, briefly considered extending Ostrom’s research program into the

domain of knowledge, taken as a resource in itself (Hess and Ostrom, 2003, 2007; Ostrom and Hess, 2007). Hess offers extended consideration of the possibilities of Ostrom's work in information and knowledge domains (Hess, 2008). This expansion of Ostrom's program has been referred to as the "New Commons," though in some cases, notably those involving cities and urban planning, "New Commons" cases do not necessarily address knowledge or information sharing institutions. Domain-specific application of Ostrom's work to empirically investigate those domains has focused particularly on open source computer programs (Schweik, 2005; Schweik and English, 2007, 2012; Schweik and Kitsing, 2010; Tenenberg, 2008) and on scientific research (Hess and Ostrom, 2006; Reichman and Uhler, 2003). Less conventional applications include the production of legislation and other law (Daniels and Hudson, 2015).

III. Introducing knowledge commons: the empirical challenge

Each of the intellectual domains described briefly in the last section shares an interest in three interlinked themes: (i) the production of innovative and creative things via collective action, (ii) structures for sharing information and knowledge resources, and (iii) governance processes that depend significantly on openness (open access to resources and/or open participation by creators and innovators) or at least with a relative disinterest in the conventional exercise of formal intellectual property rights provided by the classic public policy drivers of innovation and creativity: patent and copyright law. Some of these areas (the public domain, commons-based peer production) are described in the literature via theory (even formal models), supported by anecdote and illustration. Some, particularly open innovation, user innovation, and (to some extent) IP without IP, have developed inventories of case studies of qualitative empirical research.

To date, they have lacked a shared, comprehensive intellectual framework for identifying and understanding both the historical cases and their modern counterparts. The fragmentation of these fields, both across disciplines (law and management, for example) and within them (copyright and patent, for example) has placed certain limits on their effectiveness from an empirical standpoint. There has been little comprehensive effort to identify the virtues and drawbacks of collective action in the knowledge production context from an empirical standpoint, and there has been no comprehensive intellectual framework for doing so.

The knowledge commons research framework was developed and applied initially as an effort to provide precisely that framework, and to guide that effort.

Following the political economist Elinor Ostrom, researchers focusing on natural resources, such as forests, pastures, and irrigation systems, have collected extensive evidence of commons governance used by a wide variety of communities to manage many different types of resources, referred to collectively in this body of work as “common pool resources” (CPRs). Common pool resources are distinguished by the twin propositions that the resource is depletable or rival, and that it is difficult if not impossible to exclude users from consuming the resource. In CPR contexts and elsewhere, establishing and sustaining governance confronts various obstacles to sharing and cooperation. Some of those obstacles derive from the nature of the resources and others derive from other factors, such as the nature of the community or external influences. Ostrom was awarded the Nobel Prize in Economic Sciences in 2009 for her pioneering research demonstrating that self-governed communities can and often do overcome obstacles through purpose-built or constructed commons as well as emergent commons. Her co-Nobel, Oliver Williamson, is also celebrated for his work on economic institutions, confirming that the recognition of Ostrom is noteworthy not only for her advocacy of commons governance as such but also for her contributions to the field of comparative institutional analysis.

The knowledge commons research framework draws on Ostrom’s comparative institutionalism as well as on her research on natural resource commons. The empirical challenge is to construct and apply a technique that captures appropriately the range of potentially knowledge commons cases, respecting the tradition of open and inclusive inquiry that Ostrom established but also distinguishing Ostrom’s work when appropriate. Knowledge and information resources typically do not exhibit the characteristics of CPRs, for example. Some examples illustrate the variety of institutional arrangements and resources that are governed via knowledge commons. Most obvious may be research commons, given the importance of sharing and collaboration norms within scientific research communities (Merton, 1973). Reichman and Uhler (2003) examined scientific data commons, pressures on the “sharing ethos” within various scientific communities, and institutional means for reconstructing commons. Cook-Deegan and Dedeurwaerdere (2006) examined research commons in the life sciences and mapped out some of the relationships between the structure and function of the resource commons and the relevant community. The National Research Council of the National Academies sponsored an international conference in 2009 that explored microbial research commons. Participants examined how upstream microbial research inputs—microbial data, literature, and research materials—can be managed as commons (Reichman et al., 2016). Sharing the products of genomics research has been a fruitful area of knowledge commons research (Contreras, 2010, 2011; Contreras and Reichman, 2015).

Madison, Frischmann, and Strandburg (2010) discuss the following less obvious examples, some of which are discussed in the research literature mentioned above: intellectual property pools, in which owners of patents in a technological domain license their patents to a common “pool” from which producers of complex products can obtain all of the permissions needed to make and sell goods that use the patents (Shapiro, 2000; Merges, 1996); open source computer programs and projects, which offer users of open source programs the ability to create and share modifications to the programs (Schweik and English, 2012); Wikipedia, which offers users of this Internet encyclopedia the power to add to and edit its contents (Hoffman and Mehra, 2009); wire services for journalism, which allow individual member media outlets the opportunity to publish work produced by other members; and “jamband” fan communities, which record, share, and comment on musical performances of their favorite groups, with the permission of the artists themselves (Schultz, 2006). Madison et al. mention additional examples, including medieval guilds and the Request for Comments (“RFCs”) series that defines the technical protocols of the Internet.

IV. The knowledge commons research framework

To date, knowledge commons research has focused almost entirely on qualitative inquiry and thick description of knowledge commons cases. Reichman, Uhlir, and Dedeurwaerdere (2016) dive deeply into the laws, regulations, and practices governing the scientific communities that they collect under the heading ‘microbial research commons.’ Strandburg, Frischmann, and Madison (2017) collect qualitative case studies of commons governance in medical and public health research. Borgman (2015) synthesizes a large number of small qualitative studies of data-based research projects under a commons rubric. Data suitable for rigorous quantitative research is difficult to come by. Institutions and informal groups that manage knowledge as a shared resource may be difficult to sample, and large-scale quantitative data may be unavailable otherwise. In exceptional but important cases of open source software development communities whose collaborations are collected in a small number of umbrella websites, quantitative research has been blended with qualitative methods (Schweik and English, 2012). It is anticipated that the results of qualitative case study research may be used as the basis for future statistical analysis. In addition, the study of commons via experimental methods has begun (Janssen et al., 2014).

The primary challenge of qualitative case studies has been how to approach that process in a systematic way. Any research framework should permit research and data collection to proceed under a common set of assumptions and questions, even

if specific research methods and disciplinary foundations may vary from researcher to researcher or field to field. The framework is usable by researchers in social sciences and in the humanities, as well as by legal scholars. The framework is neither theory nor model; it does not, in itself provide a taxonomy of governance institutions. (For related work categorizing such institutions that build on collective or communal self-governance, see Dusollier, 2010; Van Overwalle, 2009.) Strong theorizing and modeling may follow the research but only light and tentative theorizing, if any, should precede it. The knowledge commons framework as described below is borrowed from Frischmann, Madison, and Strandburg (2014).

The framework builds on the Institutional Analysis and Development (IAD) framework pioneered by Ostrom and her colleagues (Ostrom, 2005), but it adds some important modifications. The IAD framework has been used principally to structure analysis of solutions to collective action problems in natural resource contexts (so-called action arenas, or action situations, in which commons participants resolve social dilemmas by applying formal and informal “rules-in-use”), such as forests, fisheries, and irrigation systems. Lobster fisheries and self-governance by local communities of lobstermen in Maine and elsewhere are often cited as accessible cases of commons governance of a natural resource. Acheson (1988) offers a readable introduction to the topic. Acheson’s work is book-ended by more recent investigation of commons governance of fisheries, including lobster grounds, by Wilson, Acheson, and Johnson (2013). The online Digital Library of the Commons (<https://dlc.dlib.indiana.edu>), a project of the Vincent and Elinor Ostrom Workshop in Political Theory and Policy Analysis at Indiana University, maintains a robust repository of scholarship on commons. Representative commons case studies available in that resource include hundreds of case studies and comparative analysis of successful and unsuccessful forest management governance in communities around the world (e.g., Gibson et al., 2007; Gibson and Becker, 2000). Empirical research has largely confirmed Ostrom’s initial hypothesis that successful commons governance involves attention to a handful of “design principles” (Ostrom, 1990, p. 90), focused on clarity of the attributes of the resource, identity and membership of the relevant community, and the community’s adoption and application of proportionate disciplinary rules on resource consumption.

IAD analysis is premised largely on choice-processing, goal-oriented behavior by self-interested individuals. It looks to explain sustainable collective action that produces measurable, productive results. The insight from applying the IAD framework to a large number of governance institutions and resources is that commons solutions can be as stable and robust as market-oriented solutions to classic “tragedy of the commons” overconsumption dilemmas involving depletable

natural resources. Shared governance of these common pool resources by community members can lead to sustainable fisheries and forests and to regular supplies of usable water.

The knowledge commons framework differs from the IAD framework in certain key respects. It does not assume the agency of choice-selecting, self-interested individuals, as the IAD framework tends to do. It accepts the role of historical contingency and of both inward-directed (selfish) and outward-directed (selfless, pro-social, or other-oriented) agents in the evolution of collective or commons institutions. At the front end of the analysis, it requires understanding the contingency of the underlying resources themselves. Natural resource commons largely take the existence of their resources for granted: fish, trees, water, and the like. Knowledge commons identify resource design and creation as variables to be described and analyzed. As intellectual resources (that is, as forms of knowledge and information), patents, copyrights, and underlying inventions, creations, and data are shaped by a variety of institutional forces rather than by nature. Critically, the knowledge commons framework does not assume that the relevant resources are rival and depletable; these are not, typically, common pool resources. The knowledge commons framework generally assumes precisely the contrary: that intangible information and knowledge resources are nonrival, nondepletable public goods. The social dilemma to be solved by a governance institution is not primarily a classic “tragic commons” overconsumption problem. Instead, it is more likely (in part) an underproduction problem and (in part) a coordination problem. In applying the framework to any particular case, care must be given to describing the authentic character of the social dilemmas present.

Against that background, the knowledge commons framework proposes to undertake comparative institutional analysis by evaluating cases of commons resources via a series of questions, or clusters of questions, to be applied in each instance. The following summary is documented in summary form at The Workshop on Governing Knowledge Commons (2014), for ease of reference.

The case study investigation begins with a general description of the history and character of the problem that is being addressed by governance in the specific case or context. This may be an explanation that is internal to the governed institution(s) (problems and explanations may emerge from stories told by participants, either today or historically, or both), or an explanation that is external to the governed institution (such as the public goods account of the rise of IP law).

One should ask whether the relevant resource or case is characterized from the outset by patent rights or other proprietary rights, as in the case of a patent pool, or

by a legal regime of formal or informal openness, as in the case of public domain data or information collected in a government archive. A particular regime might involve sharing data and information, or sharing rights in information, or sharing both. The character of the commons solution might involve coordinating holders of different IP interests or holders of different public domain knowledge resources, for example. In many respects, this cluster of queries parallels that investigation of the biophysical attributes of the natural resource that is the first part of examining a common pool resource in the natural environment.

Answering that question sets a baseline against which a commons governance regime has been constructed. Within that regime, one next asks definitional questions. What is the relevant resource and subsidiary resource units, taking into account both intangible and tangible resources and their individual or social character? What are the relationships among these resources, the baseline, and any relevant legal regime (for example, what a scientist considers to be an invention, what patent law considers to be an invention, and the boundaries of the patent itself are three related but distinct things)? What are the boundaries and constitution (membership) of the community or communities that manage access to and use of those resources? How is membership acquired (this may be informal, formal, or a blend of the two), and how is membership governed? What is good behavior within the group, what is bad behavior, who polices that boundary, and how?

Next are questions concerning explicit and implicit goals and objectives of commons governance, if any such goals and objectives exist (it is possible that commons governance regimes emerge from historical contingency rather than via planning). Is there a particular resource development or management dilemma that commons governance is intended to address, and what commons strategies are used to address that dilemma?

How “open” are the knowledge and information resources and the community of participants that create, use, and manage them? The details of the relevant aspects of “openness” should be specified, along with their contributions to the effectiveness of commons. Some commons and commons resources have precise and fixed definitions of both resources and community membership. Either resources or membership or both may be more fluid, with boundaries defined by flexible standards rather than by rules.

A large and critical cluster of questions concerns the dynamics of commons governance, or what Ostrom refers to as the “rules-in-use” of commons: the interactions of commons participants and resources. Included in this cluster of questions are: (1) details of stories of the origins, histories, and operations of

commons; (2) formal and informal (norm-based) rules and practices regarding distribution and coordination of commons resources among participants, including rules for appropriation and replenishment of commons resources; (3) the institutional setting(s), including the character of the regime's possibly being "nested" in larger scale institutions and being dependent on other, adjacent institutions; (4) relevant legal regimes, including but not limited to IP law; (5) the structure of interactions between commons resources and participants and institutions adjacent to and outside the regime; and (6) dispute resolution and other disciplinary mechanisms by which commons rules, norms, and participants are policed.

In principle, at this point it becomes possible to identify and assess outcomes. In Ostrom's IAD framework, outcomes are typically assessed in terms of the resources themselves. Has a fishery been managed in a way that sustains fish stocks over time? Do commons participants, such as the members of a fishing community, earn returns in the commons context that match or exceed returns from participation in an alternative governance context? In knowledge commons, resource-based outcome measures may be difficult to identify and assess. Sustaining the resources and their uses, individually or in combination, may be the point. Or, sustaining the community itself via its relationship to particular resources, may be the point. In a patent pool, pooled resources may constitute components of larger, complex products that could not be produced but for the pooling arrangement that reduces transactions costs among participants. Outcomes take different forms. It may be the case that patterns of participant interaction constitute relevant outcomes as well as relevant inputs. Agency, in a manner of speaking, may be less important than identity; the group and its participants, in a particular institutional setting, may be ends as well as means. Levels and types of interaction and combination matter. Participant interaction in the context of a shared resource pool or group may give rise to (or preserve, or modify) an industrial field or a technical discipline. In that specific case, such spillovers may be treated as relevant outcomes.

Having identified relevant outcomes, it becomes possible to look back at the problems that defined commons governance in the first place. Has the regime solved those problems, and if not, then what gaps remain? How do the outcomes produced by commons governance differ from outcomes that might have been available if alternative governance had been employed? Has commons governance created costs or risks that should give policy makers and/or institution designers pause? Costs of administration might be needlessly high; costs of participation might be high. A collection of industrial firms that pool related patents in order to produce complex products may engage in anticompetitive, collusive behavior. Commons governance may facilitate innovation; it may also facilitate stagnation.

V. Provisional results of knowledge commons research

Knowledge commons case studies conducted so far, primarily though not exclusively those collected in Frischmann, Madison, and Strandburg (2014), suggest a number of promising but provisional research results with respect to the eventual goal of producing a more or less comprehensive understanding of the mechanisms for effective or successful and less effective or unsuccessful knowledge commons. Those include the following:

Research counsels an expansive view of the problems to be solved by governance institutions: Knowledge commons may confront diverse obstacles or social dilemmas, many of which are not well described or reducible to a tragedy of the commons, to a free rider dilemma, or to some other generic collective action problem. Close analysis of relevant obstacles tends to suggest multiple social dilemmas that create demand for governance institutions. Strandburg, Frischmann, and Cui (2014), in a case study of a medical research consortium housed in the Rare Diseases Clinical Research Network, describe multiple dilemmas addressed by governance of a shared knowledge resource. In that case, the resource consisted of the research results of medical research on diseases that affect small patient populations. The results of that case suggest the importance of casting a wide net in general. Relevant social dilemmas may include: (i) in the case of scientific research, dilemmas attributable to the nature of the research and/or the research problem; researchers and their subjects may be few in number and/or widely distributed; other research inputs such as funding and time may be scarce or, in the case of large datasets, unmanageable via traditional analysis conducted by human beings; (ii) dilemmas attributable to the need to coordinate knowledge sharing among multiple constituencies and stakeholders that collaborate with respect to creation and management of the resource; again with respect to scientific research, interests to be accounted for include researchers, their subjects, funders, commercial partners, and the public; (iii) dilemmas arising from the need to manage rivalrous or depletable resources that are necessary inputs into production and use of the shared knowledge resources; these may include funding, time, and labor; (iv) dilemmas arising from (or mitigated by) the broader systems within which a knowledge commons institution is nested; for example, knowledge production in the modern research university is situated in the broader context of knowledge production to serve the interests of society at large; commons approaches and reliance on formal IP systems offer different modes of governance that may complement each other or that may conflict.

Relationships among governance systems are critical: Researchers should be alert to potentially complex relationships between knowledge commons and the systems within which they operate and/or are nested. The knowledge commons framework suggests a focus on the background legal rights associated with commons resources. Those legal rights may influence the shape of commons governance and/or interact with other framework inquiries in diverse ways. In some cases, the background contexts (that is, the presence or absence of formal IP rights) seem to act as external constraints on commons governance much as the biophysical characteristics of the resource do in the natural resource context. In others, background contexts shape participants' goals and objectives, participants' roles, and action arenas in diverse and dynamic ways. For example, knowledge commons and market-based institutions (or institutions for knowledge production based on different hierarchies or histories, such as government, or the military) may operate as complements, as stages in the evolution of a product or technology, or in opposition to each other.

Shared infrastructure may play a key role: Shared infrastructure appears to be often central to the success of knowledge commons institutions. In some cases, technical or technological infrastructures (such as technology platforms, databases, and bibliographies) may substitute for formal rule-based governance and discipline, easing, though perhaps also obfuscating, decision-making processes. Organizational infrastructures, such as shared coordination mechanisms (such as task forces, steering committees, technical standards and the like), may lower the costs of participation, collaboration, and research among commons participants. Ownership and/or control of infrastructure or platforms that support knowledge commons may have significant impact on knowledge commons governance. The state itself may supply important infrastructural resources for knowledge commons, consisting of funding processes, regulatory processes, or coordination institutions.

Informal governance institutions, and especially trusted leadership and shared normative framing, contributes a great deal: Informal or "social" governance, especially involving trusted leaders or decision makers, complements and at times may substitute for formal or public disciplinary institutions in many knowledge commons cases. Reliance on informal governance may grow out of relationships or norms predating the emergence of commons governance, such as norms among scientific researchers, or norms of university-based researchers and teachers, and it may evolve further, toward greater formality. A close relationship may exist between informal governance mechanisms and the need to tailor governance to the needs of small and/or local commons communities.

Commons governance often evolves over time, and commons may play an especially important role in the early stages of some industries: Commons governance may evolve as the number of participants grows or as innovation affects the nature of the shared knowledge or the balance between competition and cooperation within the group. The pattern of evolution may not necessarily follow a path from more informal to more formal governance mechanisms. Smaller or larger-scale feedback loops between smaller-scale governance institutions and larger-scale systems may be implicated.

Knowledge commons governance does not necessarily depend on one strong type or source of individual motivations for cooperation: Knowledge commons entail cooperation in the building, sharing, and preservation of knowledge resources, but the reasons individuals cooperated in particular knowledge commons may vary. Different individuals cooperate for different reasons, and sometimes a single individual had multiple motivations for cooperating, partly intrinsic and partly extrinsic, or social. Participants may have both competitive and cooperative motives, and the balance between the two may vary between individuals or change over time, depending in part on participants' overlapping roles as creators, maintainers, and/or users of shared knowledge resources. This variety of motives seems to be partially responsible for the variety of social dilemmas that arise in governing knowledge commons.

VI. Lessons for knowledge commons researchers

The knowledge commons research framework is intended to be an evolving research tool, susceptible to being improved with use over time. The knowledge commons cases collected in Frischmann, Madison, and Strandburg (2014), together with the cases referred to above as early cases identified as knowledge commons, suggest that the framework may be refined, or its application improved, or both, via considering the following perspectives. The items on this list are necessarily preliminary, given the relative youth of this field of research.

Applying the framework to some institutions that are not core examples of “knowledge commons”: Researchers may cast a wide net in defining proper subjects for study. Because the framework is primarily methodological rather than normative, it has proved useful to date in guiding study of a broad range of cases, some that were closer to what many researchers would identify as “core” or “typical” institutionalized knowledge sharing regimes (such as scientific research consortia) and others that may seem, at first glance, to be unusual subjects for a study of knowledge commons (such as the legislative process).

Taking a broad approach to identifying relevant resources and participants: The framework helps researchers to avoid tunnel vision in identifying relevant resources and participants merely by prompting researchers to ask explicitly “What are the resources?” “Who are the participants?” Research to date includes case studies that report on a broader range of resources and participants than one might associate with a typical (or stereotypical) “knowledge commons.”

Accounting more explicitly for evolution of knowledge commons governance over time: It is to be expected that knowledge commons should change over time as resources, communities of participants, and relevant formal and informal rules evolve through the decisions and actions of actors in the various action arenas. Research to date suggests a broader question about how the character and stability of some knowledge commons may be affected by changing interactions with the background environment or changes in the knowledge resources themselves. Not only do resources, actors, and rules evolve; the institutions of governance may change as well.

Beginning with goals and objectives and identifying action arenas: The basic summary of the knowledge commons research framework does not fully anticipate the potential complexity in defining action arenas for knowledge commons. In the natural resource context, the primary operational action arena for a commons regime generally is the use of a specified natural resource by a community defined by geographic proximity. (Other action arenas operate at a rule-making or governance level.) Because knowledge resources are intangible and often are created by a self-selected group of commons participants, knowledge commons often form around particular goals and objectives rather than around preexisting resources tied to particular communities or particular geographies. When that is the case, there may be several primary action arenas at the operational level, and the most important action arenas may not be immediately evident at the outset of research. To analyze a knowledge commons regime it may be most sound analytically to begin with goals and objectives, rather than resources, then to identify action arenas related to those goals and objectives, and then to identify resources, participants, rules, and so forth associated with each action arena.

In practice, use of the framework is likely to be an iterative process, in which collecting data about particular knowledge resources may lead to the identification of additional goals and objectives, which may lead to the identification of additional participants or additional shared resources and so on.

Identifying social dilemmas: Knowledge commons governance responds to a wide variety of social dilemmas in addition to the traditional free rider problem.

To analyze an action arena, it is helpful to identify the social dilemmas faced by participants. To understand the social dilemmas faced by a group of commons participants, it is also useful to study their motivations, especially since a theme that frequently appears in the case studies documented so far is diversity of participant motivation.

Identifying shared infrastructure: Future case studies may focus specifically on identifying infrastructural resources created or used by the commons institution. In some cases, such as open source software, it will be important to include infrastructural constraints in the analysis of an action arena's "rules-in-use" in order to get a complete picture of commons governance.

Identifying both nonrivalrous and rivalrous resources: Although the study of knowledge commons focuses on the sharing of intangible, nonrivalrous resources, it is important to identify any rivalrous resources that are important to a particular action arena. Social dilemmas for knowledge commons governance can and do arise from competition or conflict over the allocation of scarce or nonrivalrous resources.

Identifying dilemmas and action arenas associated with boundary management: Knowledge commons may have different types and degrees of "openness." In particular, because knowledge resources are nonrivalrous, knowledge commons are likely to have to deal with multiple constituencies, including as users, creators, managers, curators, and subjects of the knowledge resources. These different constituencies may make different and sometimes conflicting demands on commons resources. It is important when identifying goals and objectives and action arenas to be aware of the possibility that important action arenas may be devoted to managing overlaps among these interests and boundary conflicts among different participants.

VII. Questions to be answered

The field of knowledge commons studies is still in its infancy, both substantively and methodologically. Knowledge commons is in the process of moving from a place of relative obscurity and marginalization in the context of studies of intellectual property and innovation generally, to a place where its approach to comparative institutional analysis – what modes of governance support innovation and creativity, and in different ways – appears to be gaining adherents among researchers.

Still, numerous questions about knowledge commons remain to be explored. Among them are the following:

Systematization of cases: As more cases of knowledge commons are studied and documented, the task of synthesizing the data generated will become more important and more pressing.

Empirical methods: Investigation of knowledge commons need not be limited to qualitative case study research. Experimental methods, examining the strengths and limits of self-governed collaboration and cooperation among groups in knowledge and information settings, may prove useful.

Alignment with other literature: The related fields of research identified earlier in this chapter may offer important lessons for knowledge commons researchers; some of the cases developed in those fields may be adapted as data for the broad systematization of the field. How that task might be accomplished remains to be developed.

Alignment with practice: The case study approach that knowledge commons research has taken so far offers both opportunities to examine contemporary commons institutions and also the challenge of adapting the research to the needs and goals of contemporary practitioners of knowledge commons governance (Bollier and Helfrich, 2012).

Evaluation and normative implications: Knowledge commons research is presented today primarily in descriptive terms; the questions concern the mechanics of successful and unsuccessful knowledge commons institutions. More precise guidelines and measures for understanding success are missing, at present, whether from a social welfare standpoint or from an expressive or social meaning standpoint. The fact that knowledge commons offers prospects for sustained governance of an innovation domain, despite the presence of formal IP rights or despite their absence, offers an implied normative claim regarding the value and purpose of knowledge commons. That normative claim has not yet been developed in detail.

Design principles: Ostrom's work on commons governance is celebrated in part because she reduced her investigation of commons to a series of so-called "design principles" for well-functioning, long-enduring commons regimes (Ostrom, 1990, p. 90). Differences between knowledge and information resources and the natural resources commons that Ostrom focused on suggest that those design principles should not be carried over uncritically into the knowledge and

information domain. Is a comparable set of design principles feasible? If so, what would those principles look like? The answers will have to await further research.

VIII. Conclusion

There are many different knowledge commons. Yet we know very little about them. How do such commons work? Where do they come from, what contributes to their durability and effectiveness, and what undermines them? When are commons governance institutions preferred for managing the production and use of knowledge and information resources? When are market mechanisms preferred? When is state or other centrally-coordinated governance superior? This chapter provides an overview of the present state of research into these questions, and a look forward at the research possibilities that the field offers.

In the past decade, scholars in various disciplines have become interested in studying these types of commons, and some have begun case studies. However, their research often is focused narrowly on the specific case or an isolated area, such as academic publishing or open source software, and fails to investigate the broader institutional questions and to appreciate the need for systematic analysis. As a result, they tend to consider only a limited number of descriptive variables, which makes integration and learning from a body of case studies quite difficult.

Building on Ostrom (1990), Ostrom (2005), and Hess and Ostrom (2007), Frischmann, Madison and Strandburg developed a framework for the systematic study and comparative analysis of knowledge commons. (Madison et al., 2010; Frischmann et al., 2014). The underlying nature and structure of the inquiry as well as the focus on complexity, context, communities, and institutions unites this knowledge commons project with Ostrom's legacy. Nonetheless, Ostrom's Institutional Analysis and Development framework for researching commons has been adapted and extended to account for significant differences between natural resource commons and knowledge commons. Most obviously, the resources are different, and as a result, the obstacles that must be overcome for institutionalized sharing to work are different. Thus, for example, the governance structures for knowledge commons manage existing resources as well as production and integration of new resources. Another interesting complication is the complex role of legal institutions in delineating intellectual resources, for example, by defining what constitutes the expression in software that might be governed by open source software licenses. Notably, this complication raises resource boundary and corresponding resource management issues that may be less salient for natural resource commons. These and other differences call for a series of inquiries specifically tailored to knowledge commons.

This chapter provides a summary of the research framework that applies those inquiries on a systematic basis, as well as a brief review of related research areas. It summarizes the findings of case study research on knowledge commons to date, and points researchers toward an updated set of research questions on both large and small scales. Details on the knowledge commons research framework can be found at Workshop on Governing Knowledge Commons (2014).

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