REVIEW

Commons and Growth: The Essential Role of Open Commons in Market Economies

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Infrastructure: The Social Value of Shared Resources
Brett M. Frischmann. Oxford, 2012, Pp ix, 417.

INTRODUCTION

Complex modern market economies would cease to function were they not pervaded by commons. These are not commons on the model of the centuries-old irrigation districts or pastures that inspired and shaped three decades of the study of the commons, pioneered by Elinor Ostrom.[1] Rather, these are commons that all modern economies live and breathe on, commons over which no one exerts exclusionary proprietary claims and that are available for all to use on symmetric terms. These commons are the highways and roads that make arteries and capillaries, the sidewalks and squares that facilitate the flow of commerce and public life in the world's metropolitan engines. These are the utilities—electricity, water, and sewage to power, feed, and cleanse—and the major shipping lanes and container standards that make trade flow smoothly. These are also math and geometry, scientific data, ideas, knowledge, and truths ascertained. So too is the Internet, from its very core standards to the software that runs the overwhelming majority of servers, and the rule of law to govern them all.

None of these is built on a classic model of property rights and free market exchange between an owner—who centralizes in a single decision maker all rights to exclude, use, manage,

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[1] See generally Elinor Ostrom, *Governing the Commons: The Evolution of Institutions for Collective Action* (Cambridge 1990).

and dispose of the object of the property—and all others, an owner whose exclusive control thereby centralizes the coordination among all comers and their diverse valuations of the resource. Sure, there are private property roads; there are proprietary power generators, pumps, and cesspools or septic tanks. But these are a sideshow. The main event for all these systems *is* open commons: systems that eschew the core of property—the allocation of asymmetric rights to exclude, use, and manage the resource set whose use they govern—and instead offer (a) symmetric access and use privileges to (b) an open class of potential users. The price system works when there is asymmetric allocation—it consists in the use of prices to determine comparative availability of the resource for competing uses. Symmetric-access privileges, even when priced, abandon the use of price for fine-grained allocation, and rely instead on any one of a range of alternative systems: queuing being the most common, social determination an oft-found alternative.

Brett Frischmann's new book, *Infrastructure: The Social Value of Shared Resources*, is the most recent and sustained contribution to the still-small but growing literature seeking to explore the central role of large-scale open commons in modern economies. It is an ambitious effort and invites us to think about four major questions: first, the question of the provision of classic public goods and a range of quasi-public goods; second, the question of property versus commons as institutional forms for managing the production and use of a wide range of resources and goods that play a critical role in any well-functioning capitalist economy; third, the respective roles of market production, public provisioning, and social production in providing these critical resources; and fourth, the costs and benefits of general institutional solutions and analyses as compared to analyses that are more context specific to spheres of action.

In this, the book is an important contribution to a process of trying to mesh the longstanding work on the commons in the Ostrom school with the increasing pervasiveness of commons at the foundation of the networked information economy: knowledge and innovation, communications and computation. Ostrom herself began to explore this convergence over the past decade,[2] in particular as applied to a wide range of new commons

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[2] See Elinor Ostrom, *Understanding Institutional Diversity* 219–88 (Princeton 2005).

in sustained collaboration with Charlotte Hess.[3] Carol Rose early pointed in this direction in *Comedy of the Commons*.[4] But most of the work on understanding the role of the commons in contemporary society and economy developed over the course of the 1990s in a legal literature focused on the networked information economy, where "tragedy of the commons" is a fundamentally flawed metaphor: studies of the public domain in copyright and patent,[5] and studies of communications networks and the then-emerging Internet.[6] Frischmann here follows up on his original expansion of insights from the scholarship on the networked economy to "infrastructure" generally,[7] with infrastructure taking on an extremely expansive definition.[8]

Frischmann's core claim is that (a) there is a set of resources whose use creates large positive externalities, particularly through facilitating downstream production activities of public and social goods (pp 61–66); (b) these resources are either nonrival or nonscarce over a sufficient range of their uses and renewable over the range of nonscarcity that the costs associated with implementing a private-property system during the noncongested periods outweigh the benefits of improved management during congestion (pp 61–63);[9] and (c) these resources are often, and should be from an economic perspective (the core purpose of the book is to make the economic argument), subject to commons management, rather than property, where "commons" is marked primarily by emphasis on availability to all, of some

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3 See generally, for example, Charlotte Hess and Elinor Ostrom, *Ideas, Artifacts, and Facilities: Information as a Common-Pool Resource*, 66 L & Contemp Probs 111 (Winter-Spring 2003); Charlotte Hess and Elinor Ostrom, *A Framework for Analysing the Microbiological Commons*, 58 Intl Soc Sci J 335 (2006); Charlotte Hess and Elinor Ostrom, *Introduction: An Overview of the Knowledge Commons*, in Charlotte Hess and Elinor Ostrom, eds, *Understanding Knowledge as a Commons: From Theory to Practice* 3 (MIT 2007). See also generally Charlotte Hess, *Mapping the New Commons* (Syracuse University Working Paper, July 2008), online at http://surface.syr.edu/cgi/viewcontent.cgi?article=1023&context=sul (visited Sept 15, 2013).

4 See Carol Rose, *The Comedy of the Commons: Custom, Commerce, and Inherently Public Property*, 53 U Chi L Rev 711, 778–80 (1986).

5 See notes 51–65 and accompanying text.

6 See notes 66–77.

7 See generally Brett M. Frischmann, *An Economic Theory of Infrastructure and Commons Management*, 89 Minn L Rev 917 (2005).

8 "This book views infrastructure capaciously, emphasizing the functional role of infrastructure. . . . [I]nfrastructure resources are *shared means to many ends*" (p 4).

9 He calls these "partially (non)rival" (p 30), which may be more confusing than helpful, since they are not in fact nonrival at all, but rather, as the text says, nonscarce over substantial ranges of their use.

level of access to the resource, on nondiscriminatory terms (pp 91–114).

This Review is part review, part observations that reading the book elicited. Part I outlines the intellectual history of commons studies, and in particular, makes an effort to diagnose the relations between the more famous Ostrom school of commons studies—historically focused on the management of natural resources under limited common property regimes (CPRs)—and the open-commons school that Internet studies and intellectual property literature in particular developed over the past twenty years. Part II will outline Frischmann's argument and its contribution to the open-commons school. The contribution is significant; in particular, Frischmann pushes us to think of the role of commons well beyond the public domain in intellectual property or common carriage, open standards, and free and open source software in communications and Internet systems. I will also suggest certain ways in which Frischmann's ambition to create a theory of infrastructure generally, stated almost exclusively in terms of demand-side market failures, and his effort to yoke open commons and CPRs together create internal tensions in the work as a guide to infrastructure policy and as a theory of commons.

Part III is an effort to clarify and expand an important aspect of the argument for open commons that Frischmann suggests in the book. It offers an argument, based on uncertainty and action in error-prone systems characterized by uncertainty, for why modern complex economies and societies in particular depend so heavily on open commons and institutional forms that eschew exclusive proprietary control over critical resources in favor of symmetrically defined access and use privileges (p 93).

In a world with persistent uncertainty and positive transaction costs, commons offer the benefits of *freedom to operate* that a classical perfect market is supposed to provide in the absence of transaction costs and with perfect information. The symmetric-use privileges that typify the most important commons—like highways or electricity, information or the Internet—avoid the need for transactions at the margin and allow for low-cost exploration in an uncertainty space through experimentation, reassessment, and adaptation to new information. Commons obtain this high flexibility at the cost of the *power to appropriate* the benefits of the new action through control of the resource set that enabled it, requiring enterprises to seek different leverage

points and strategies of appropriation.[10] The elegant institutional parsimony of property rights, by contrast, is that, under certain well-understood conditions, they combine flexibility, information gathering, and an appropriation mechanism into a single institutional entity and can be brought to bear at the point of action—the transaction. But under the actual conditions of complex modern economies—which exhibit transaction costs and, more importantly, are pervaded by uncertainty (not merely risk) and replete with unknown unknowns—property can often slow down both owners and potential users.

When we use the words "modern society is complex," we usually mean at least three analytically distinct things, all correct: First, we mean that social behaviors at the scales of the interconnected systems we inhabit and rely on, and that structure our capabilities and susceptibilities, are "complex" in the technical sense—that is, they display nonlinear emergent properties and are sensitive to initial conditions and small perturbations. Second, we mean that they exhibit stochasticity, or a random element, even where we think that the dynamics we can observe, such as a set of institutions and behaviors we anticipate in response to them, are linear. And third, we mean something not about the world, but about our tools: that the techniques we possess require a level of simplification for tractability and that the information lost in the process of rendering the problem tractable creates systemic error that is not itself susceptible to solution within the techniques we possess. The increasing recognition of the importance of tacit knowledge follows from the third meaning. A gestalt, "muscle memory" understanding of a situation and the likely behaviors and approaches to its solution is a method of practice that can address this problem, not formally, but practically. The former two meanings of complexity suggest that unpredictability and uncertainty are simply properties of the world of social behavior; there is no "solution" to them that involves perfecting tools to the point of overcoming, at least hypothetically, the last problem. Solutions, behaviors, and practices will necessarily be an imperfect response to their dynamic environment, and they must necessarily integrate experimentation, failure, learning, and adaptation alongside

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[10] See Yochai Benkler, *Growth-Oriented Law for the Networked Information Economy: Emphasizing Freedom to Operate over Power to Appropriate*, in Kauffman Task Force on Law, Innovation, and Growth, *Rules for Growth: Promoting Innovation and Growth through Legal Reform* 313, 313–14 (Kauffman 2011).

planning as a core design element.[11] This is pretty standard fare as an argument for markets over planning bureaucracies. It is also an argument against the possibility of perfection in markets. Like markets, commons are necessarily imperfect. What commons offer is a space for experimentation, learning, and adaptation whose limitations are uncorrelated with the limitations of the property system. They offer another degree of freedom in the exploration of solution spaces to the problems that human existence posits.

Commons offer freedom to operate that allows agents to identify opportunities for action, resources, and desirable outcomes, and to act on those opportunities without need for translating the required resources, actions, and outcomes into a formalized set of calls on a resource system—either market or managerial (state or firm). This freedom to operate can be conceptualized as having an option value marked by the degree of uncertainty and the value of low-cost experimentation and flexibility to act on locally obtained information (itself sometimes tacit or difficult to communicate) to deal with that uncertainty; its cost is the lost appropriation mechanism and losses due to congestion (where it occurs).

Rapid growth and change—which require rapid innovation, experimentation, and adaptation, as well as action in an ever-growing global economy where changes, opportunities, and innovations can come from an ever-wider range of actors—depend on significant levels of freedom to operate: to sense, experiment, evaluate, and act, and therefore require substantial commons in resources. That is why so much of the work on the benefits of commons has come out of the literature on the Internet. Economic models geared toward stabilization, rent extraction, and efficiency in the face of persistent scarcity given a relatively slow-moving horizon of production capacities can afford to depend more completely on property or managerial competence, whether in a firm or a state. But the same is not true under conditions of continuous change and uncertainty whose description resists translation into units susceptible to efficient communication in markets or hierarchies. The checkerboard of private property and roads and highways that typifies our metropolitan areas is a strong visual metaphor for what is true, but invisible,

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[11] See F.A. Hayek, *The Use of Knowledge in Society*, 35 Am Econ Rev 519, 530 (1945).

in our institutional landscape as well: the checkerboard of property and commons in the complex modern economy as a whole balances security in holdings with freedom of action.

There is a tension between the two major lines of commons literature. Growth-oriented commons necessarily occur at scales incompatible with the congestion solutions developed in common property regimes. They are oriented toward optimizing freedom of diverse and uncoordinated action, rather than coordination among known, sustainable practices that fit a highly refined understanding of the local context. The hallmark of the Ostrom school of commons studies was to highlight the persistent advantages of local knowledge in a highly complex and variable natural and human environment.[12] Locally developed institutions and practices outperformed formalized state-based systems: both classical private property and the expert regulatory state. The study was rich, yet—for all but its last decade or so—self-consciously limited to smallish-scale units where provisioning, management, and disinvestment or congestion avoidance were all rolled up into a single institutional framework built around specific local knowledge, institutions, and practices.[13]

The empirically grounded insistence on the advantages of the local as the domain of solutions to collective action problems puts the lessons of this work in tension with the scale at which the commons operates in complex modern economies. Highways cannot be regulated by a limited set of users who are permitted to share them because their very role is to be open to everyone. So too with electricity, shipping lanes, and so forth. Provisioning cannot be roughly shared among all users of the open commons because its whole purpose is to permit a highly diverse, unknown, and dynamically changing set of actors to experiment in reliance on the presence of the resource rather than to engage in its provision. And yet, without governance, the very freedom to operate that open commons provide also creates the risk of congestion, pollution, or disinvestment. Certainly, the open commons of the air supported industrial development by giving freedom to operate and avoiding having to ask permission to emit pollutants. Certainly, the digital commons permitted widespread innovation in peer-to-peer networks, but the freedom to

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[12] See Ostrom, *Understanding Institutional Diversity* at 279–80 (cited in note 2).

[13] Compare Elinor Ostrom, *Governing the Commons: The Evolution of Institutions for Collective Action* 26 (Cambridge 1990), with Ostrom, *Understanding Institutional Diversity* at 219–88 (cited in note 2).

innovate led to (among other things) piracy sites like Napster, long preceding efforts to think of how, once music is free, society sustains a class of professional artists. And so the challenge remains to unify these two very different conceptions of the commons: (1) the conception where commons use small-scale production and governance systems that can manage provisioning, congestion, and disinvestment through highly particular and local practices and institutions; and (2) the conception where commons operate as an integral part of open, global, complex modern economies, and for which neither property nor regulation seems perfectly apt but, because of its necessary scale, cannot simply cut and paste the traditional Ostrom school commons approaches either.

Part IV will offer an initial synthesis of the Ostrom school's insights into collective governance and context-specific institutional analysis and the open commons given the persistent imperfection of all the systems we occupy—be they hierarchical governments or firms, or distributed actors in markets or social interactions. It embraces an approach that Frischmann's work with Katherine Strandburg and Michael Madison has championed.[14]

I. A BRIEF INTELLECTUAL HISTORY OF TWO THEORIES OF THE COMMONS

The first and most famous line of work on the commons is anchored in Elinor Ostrom's 1990 book, *Governing the Commons*.[15] That book marked a turning point in the legitimacy of talking about the commons on the background of a dominant neoclassical understanding of property and the "tragedy of the commons."[16] The second line began with Carol Rose's *Comedy of the Commons*[17] in 1986, but was most extensively developed in work on the Internet and the role of the public domain in the production of knowledge, information, culture, and innovation.

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[14] See Michael J. Madison, Brett M. Frischmann, and Katherine J. Strandburg, *Constructing Commons in the Cultural Environment*, 95 Cornell L Rev 657, 675–83 (2010); Michael J. Madison, Brett M. Frischmann, and Katherine J. Strandburg, *The University as Constructed Cultural Commons*, 30 Wash U J L & Pol 365, 387–400 (2009).

[15] Ostrom, *Governing the Commons* (cited in note 13).

[16] For the seminal work on the tragedy of the commons, see Garrett Hardin, *The Tragedy of the Commons*, 162 Science 1243, 1244–45 (1968).

[17] Rose, 53 U Chi L Rev 711 (cited in note 4).

A. The Ostrom School: Collective Action and Common Property Regimes

Ostrom's work came out of her collaboration with her husband, Vincent Ostrom, in the Workshop in Political Theory and Policy Analysis at Indiana University; this work was fundamentally a branch of public choice, part of the conversation on the logic of collective action.[18] Its primary focus was on how groups can solve the problems of collective action without relying on the state for either of the two then-dominant models: directly regulating behavior or defining and enforcing private property rights.[19] The work emphasized detailed studies of a carefully delineated set of institutions—limited CPRs—applicable to a very carefully defined class of physical resources, common-pool resources. Using highly context-specific, detail-rich case studies of these settings, under the Institutional Analysis and Development (IAD) framework she developed,[20] and abstracting from them to the mainstream game theory and public choice theory, Ostrom was able to carve out a distinct and robust field that had enormous real-world implications for development policy and that played a critical role as a major intellectual critique of the dominant model that privileged property rights as the core solution to collective action problems. CPRs range from the lobster gangs of Maine,[21] through Spanish irrigation districts,[22] to Japanese fisheries.[23]

Until the mid-1990s, "the bulk of commons research [was] aimed at natural-resource commons, particularly forests and land, fisheries, and water resources."[24] Charlotte Hess, who conducted the most extensive reviews of diverse scholarly work on commons, and who collaborated extensively with Ostrom in trying to mesh the pre-mid-1990s Ostrom school with the "new commons" or "knowledge commons" work, showed that this

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[18] See, for example, Mancur Olson, *The Logic of Collective Action: Public Goods and the Theory of Groups* 1–3 (Harvard 1971).

[19] See Hardin, 162 Science at 1247 (cited in note 16). See also Olson, *The Logic of Collective Action* at 101 (cited in note 18).

[20] See Elinor Ostrom, *Background on the Institutional Analysis and Development Framework*, 39 Pol Stud J 7, 9–11 (2011).

[21] See Edella Schlager and Elinor Ostrom, *Property-Rights Regimes and Natural Resources: A Conceptual Analysis*, 68 Land Econ 249, 257–59 (1992).

[22] See Ostrom, *Governing the Commons* at 69–82 (cited in note 13).

[23] See Arif Satria, Yoshiaki Matsuda, and Masaaki Sano, *Contractual Solution to the Tragedy of Property Right in Coastal Fisheries*, 30 Marine Pol 226, 233–34 (2006).

[24] Hess and Ostrom, *Introduction: An Overview of the Knowledge Commons* at 6 (cited in note 3).

emphasis characterized the overwhelming majority of studies of the nontragic commons in that earlier period.[25] In that context, the hallmark of the IAD/CPR line of work was a focus on non-state-based, mostly local, institutional designs for sustainable governance of resources limited to a defined set of claimants: farmers who are part of an irrigation district, harvest a local forest, or share a pasture or fishery to which they all lay claim in common vis-à-vis the rest of the world. These institutional designs were CPRs—property regimes applied to resources that require larger-scale utilization than would be efficient in small, individually owned parcels, but whose subtractibility characteristics were such that they could not be open to the world at large.

The defining feature of this work was the absence of a state-created property system, not the absence of proprietary claims of exclusion, use, and disposition, either limiting use to the group or among group members. Nowhere is this more clearly seen than in the fact that the irrigation system of Alicante in Spain is one core instance that Ostrom describes in *Governing the Commons*.[26] There, farmers have a highly fluid, divisible, and tradable set of claims embodied in scrip-denoted entitlements to minutes of water flow, and engage in an active market for the exchange of this scrip. If Alicante is a "commons," then what makes it a "commons" must be an absence of a *state-created* property system, not the absence of well-defined, enforced, divisible, private property rights. The primary policy implication of this line of work therefore was that in the management of resources, introducing a government management policy intended to rationalize use of a system, *either by direct regulation or by parceling out the property to more classically defined property rights*, will undermine a well-functioning, collectively created system better tailored to local conditions than either standardized institutional framework (property or regulation).[27] Ostrom and the scholarly work that followed her suggest that both knowledge and motivation are local and sticky, and that abstract, general systems like administrative regulation at the level of the state- or property-based markets will tend to lose information and undermine motivation.

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[25] See Hess, *Mapping the New Commons* at *20–28 (cited in note 3).

[26] Ostrom, *Governing the Commons* at 78–82 (cited in note 13).

[27] See Hess and Ostrom, 66 L & Contemp Probs at 123 (cited in note 3).

To repeat, there are at least two critical insights here. The first is that people can in fact come together and solve collective action problems in sustainable ways, without state law, either regulatory or property/contract. The second is that individual private property regimes enforceable by general courts of law, just like administrative regulation, require a degree of abstraction from local conditions, and that this abstraction can lead to substantial knowledge and motivational loss, which, in turn, may lead to lower performance for the resource system governed by either one of these more "rationalized" forms. While Alicante is the most extreme version within these systems, many of the systems embody various levels of freedom for individual members to manage extraction and use within the collectively held resource system, lacking primarily the right to alienate their set of privileges to someone outside the system or to make uses outside the bounds of the set practices.

But CPRs are decidedly *not* highways or the Internet protocol, which anyone can use under symmetric terms. CPR studies insist on "the difference between property regimes that are *open-access*, where no one has the legal right to exclude anyone from using a resource, and *common property*, where members of a clearly defined group have a bundle of legal rights including the right to exclude nonmembers from using that resource."[28] In other words, some of the core elements generally identified by the Ostrom school as necessary to successfully managed commons fundamentally conflict with the core institutional characteristics of many of the most critical commons in complex modern economies. To overcome this gap, in her most recent work, Ostrom, collaborating with Hess, sought to abstract from the original constraints.[29] For what Hess and Ostrom were now describing as "knowledge commons," the most useful insight from the Ostrom school work was the IAD methodological framework: the emphasis on a context-specific, recursive, empirically grounded approach that led her to the original insights, but applied to very different contexts that may, in turn, yield very different models of governance. I return to this call, and to its most direct application in efforts by Frischmann, Strandburg, and Madison, in Part IV.

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[28] Id at 121.

[29] See Elinor Ostrom and Charlotte Hess, *Private and Common Property Rights*, in Boudewijn Bouckaert, ed, 5 *Property Law and Economics* 53, 56–57 (Edward Elgar 2d ed 2010).

But it is important to separate out work within the Ostrom school (and work that seeks to apply Ostrom's methods with nuance) from the more troubling phenomenon of mechanical application. The well-earned legitimacy and prominence of Lin Ostrom personally, and the CPR literature more generally, has led her theories to be misapplied where they do not fit. For example, a recent analysis of unlicensed spectrum management by highly prominent economists states that "[t]he Nobel laureate Elinor Ostrom has written extensively on the diversity of governance systems for managing common pool resources. . . . As the Wi-Fi example suggests, the regulation of unlicensed spectrum can be viewed as a successful example of a *managed commons* approach."[30] This is sheer bunk. WiFi, and all industrial, scientific, and medical (ISM) radio bands, are open-access commons par excellence. Anyone can build any device they wish that emits radiation in these bands, deploy it wherever they wish, and use it for whatever purpose they wish, subject to generally applicable, symmetric power limits. Despite repeated and vociferous protestation from economists who said that congestion and a tragedy of the commons would necessarily follow,[31] WiFi and other standards that rely on the open access ISM bands now serve 70 percent of the smart grid communications market in North America, 80 percent of its wireless health care market,[32] all toll collection systems,[33] and all currently operating mobile payment systems.[34] These are but a few of many instances where *open-access-spectrum commons*, no different in its fundamental institutional structure from the open highway system, has come to dominate markets that require large amounts of wireless capacity and needed substantial rapid innovation to serve that capacity. But to understand why that is so, one needs an entirely different theory of the commons.

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[30] Paul Milgrom, Jonathan Levin, and Assaf Eilat, *The Case for Unlicensed Spectrum* *14 (working paper, Oct 23, 2011), online at http://ssrn.com/abstract=1948257 (visited Sept 15, 2013).

[31] See, for example, Thomas W. Hazlett, *The Wireless Craze, the Unlimited Bandwidth Myth, the Spectrum Auction Faux Pas, and the Punchline to Ronald Coase's "Big Joke": An Essay on Airwave Allocation Policy*, 14 Harv J L & Tech 335, 491 (2001).

[32] See Yochai Benkler, *Open Wireless vs. Licensed Spectrum: Evidence from Market Adoption*, 26 Harv J L & Tech 69, 72 (2012).

[33] Id at 120.

[34] Id at 72.

B. Productive Open Commons in Dynamic Society: From the Open Road to Networked Society

That "other theory"[35] of the commons was initially driven by legal scholars, rather than political scientists or economists, because its core focuses on the detailed characteristics of the institutional design of critical systems in emerging modern economies. In particular, it sought to understand instances where, instead of asymmetric exclusion and management rights based in property, we see extensive use of symmetric access and use privileges based in commons and the public domain.

1. Highways, waterways, and trade.

The productive commons was introduced in contemporary legal debates with Carol Rose's notion of "inherently public property."[36] Rose was trying to untangle the then-recent emergence of the "public trust" doctrine, which flew in the face of the increasingly dominant neoclassical economics bent in legal literature at the time.[37] Rose located the public trust doctrine in a broader line of cases that went in exactly the opposite direction to what then-prevalent theories predicted. Instead of defining and refining property rights in response to increased value of the resource, these cases redefined property rights in those resources so as to *reduce* private power to exclude from those resources and increase public access, creating use rights for a general, undifferentiated public. Relying on historical analysis, Rose showed that the public trust cases were part of a line of longstanding doctrines in property law, most prominently concerning roadways and navigable waterways. She wrote, "The more radical feature of these cases is precisely their seeming defiance of classical economic thinking and the common law doctrines so markedly mirroring that theory: they show a preference for public access, superior to the right to exclude that is the supposed hallmark of private property."[38] Public-goods analysis alone did not explain the open-access model, because for public goods, "[c]onventional wisdom instructs that in such cases, the most productive solution would be for government to assume some or all of the rights of ownership and control over the property,

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[35] See note 17.

[36] See Rose, 53 U Chi L Rev at 720 (cited in note 4).

[37] See id at 739

[38] Id at 716.

and to use its powers to correct the market's misallocation."[39] As she sums it up:

> [I]n the conventional lore, markets are based on private rights or, when markets fail, property may be governmentally managed in the interests of aggregate efficiency. Yet these two options do not logically exhaust all the possible solutions. Neither can they adequately describe all that one finds in the recorded history of property in the Anglo-American universe. In particular, there lies outside purely private property and government-controlled "public property" a distinct class of "inherently public property" which is fully controlled by neither government nor private agents.[40]

Here, "inherent" meant that common law doctrine created rights in roads, waterways, or public squares for the unorganized public, rather than a particular subset of users or government as proprietor.[41] Roads and navigable waterways are definitely *not* CPRs. Indeed, Rose showed that the doctrines of prescription for roads, for example, explicitly excluded cases where specific known individuals, however many, were permitted to cross a road: "[B]efore property could be claimed as 'public,' its users had to comprise an indefinite and open-ended class of persons: as one court said, the road had to be open to 'strangers.'"[42] Navigable waters included a similar requirement of open-class accessibility.[43] These *open* commons are the very foundation of commerce. Rose's primary economic explanation of why these doctrines emerged relied on the very early versions of what we now call network effects: demand-side economies of scale mean that a regime that makes it easier for more users to use these open-access systems increases their value to all.[44] But increasing returns to scale on the demand side seem to tell only part of the story, and as network economics itself developed and was refined over the late 1980s and 1990s, it seems clear that some other kinds of externalities are required to explain the large benefits of open-access commons necessary to outweigh the well-known costs. That work now shifted to the new world of the network of networks—the Internet—and the new dominance of

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39 Id at 719.

40 Rose, 53 U Chi L Rev at 720 (cited in note 4).

41 See id at 721.

42 Id at 762, citing *Rung v Shoneberger*, 2 Watts 23, 25–26 (Pa 1833).

43 See Rose, 53 U Chi L Rev at 764–65 (cited in note 4).

44 See id at 768–70.

innovation and creativity to growth and development, and consequently new copyrights and patents scholarship and the category of "intellectual property" (a term whose use primarily dates back to the mid-1980s).[45]

2. Open commons in networked society and economy.

Information is strictly nonrival (the marginal cost of producing an instance once the original information has been produced is zero) and is both an input and output of its own production (we use information to make information). A positive price on information, once produced, therefore leads to underutilization, and some of that underutilization includes underproduction of new information.[46] For these same reasons, many economists,[47] and some legal scholars,[48] have long recognized that creating clear property rights in information goods, patents, and copyrights can have negative effects both on welfare (because of the nonrivalry and deadweight losses) and on innovation (because of the "shoulders of giants" effect[49]). Moreover, this basic tension between a right to appropriate and freedom of access for creative and innovative reuse has been a bedrock of debates over copyright

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[45] See Mark A. Lemley, *Property, Intellectual Property, and Free Riding*, 83 Tex L Rev 1031, 1033–34 (2005). See also Richard M. Stallman, *Did You Say "Intellectual Property"? It's a Seductive Mirage* (Free Software Foundation), online at http://www.gnu.org/philosophy/not-ipr.html (visited Sept 15, 2013).

[46] See generally Jessica Litman, *The Public Domain*, 39 Emory L J 965 (1990) (examining the role of the public domain in copyright as a tool that augments innovation by providing material from which others can draw).

[47] This has been a standard argument since Richard R. Nelson, *The Simple Economics of Basic Scientific Research*, 67 J Polit Econ 297, 302 (1959). For another discussion of the perverse effect on incentives of open rights to information, see Kenneth J. Arrow, *Economic Welfare and the Allocation of Resources for Invention*, in National Bureau of Economic Research, *The Rate and Direction of Inventive Activity: Economic and Social Factors* 609, 616–17 (Princeton 1962).

[48] See Benjamin Kaplan, *An Unhurried View of Copyright* 124–25 (Columbia 1967); Stephen Breyer, *The Uneasy Case for Copyright: A Study of Copyright in Books, Photocopies, and Computer Programs*, 84 Harv L Rev 281, 350–51 (1970); David Lange, *Recognizing the Public Domain*, 44 L & Contemp Probs 147, 165 (Autumn 1981).

[49] William Fisher was slightly ahead of the curve in applying this to a new justification of fair use, and in particular the emphasis on transformative use that later became the hallmark of contemporary fair use law. See William W. Fisher III, *Reconstructing the Fair Use Doctrine*, 101 Harv L Rev 1659, 1702–04, 1746 (1988) (explaining deadweight loss, but emphasizing an Aristotelian, human-flourishing approach to defining the normative desirability of balanced copyright, rather than an economic perspective on specifically open commons).

and patent for over two hundred years.[50] It is therefore unsurprising that the public domain in copyright and patent became the first locus for developing the idea that open commons were a critical element of modern complex society and economy, a project that unfolded mostly over the course of the 1990s and early 2000s.

In 1990, Jessica Litman offered the first overview of the wide range of doctrines in copyright law that construct this productive public domain.[51] She wrote, "The public domain should be understood not as the realm of material that is undeserving of protection, but as a device that permits the rest of the system to work by leaving the raw material of authorship available for authors to use."[52] In particular, she began to draw the work on the public domain into the sphere of work on the commons: "In the intellectual property context, the term describes a true commons comprising elements of intellectual property that are ineligible for private ownership. The contents of the public domain may be mined by any member of the public."[53] The direct tie between the public domain and modern economy, in turn, was most urgently driven by the awkward fit between software and the traditional categories of copyright and patents and the centrality of software innovation to the most advanced areas of modern economies. This tension made amply clear that the *absence* of either property rights or well-defined, limited CPRs was necessary to support the kind of rapid, cumulative, decentralized innovation that the software industry was experiencing in the late 1980s and early 1990s.[54] No scholar explored this tension and communicated its effects to lawyers and nonlawyers alike more than Pamela Samuelson.[55] Samuelson became the leading mentor of a generation of copyright scholars working on copyright in the digital environment.

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[50] See James Boyle, *The Public Domain: Enclosing the Commons of the Mind* 17–41 (Yale 2008); Josh Lerner, *150 Years of Patent Protection*, 92 Am Econ Rev 221, 222 (2002).

[51] See Litman, 39 Emory L J at 970–77 (cited in note 46).

[52] Id at 968.

[53] Id at 975, citing, among other sources, Rose, 53 U Chi L Rev 711 (cited in note 4).

[54] For an early version of people who develop software understanding the core of this dynamic, see Simson L. Garfinkel, Richard M. Stallman, and Mitchell Kapor, *Why Patents Are Bad for Software,* 8 Issues in Sci & Tech 50, 53 (1991).

[55] For merely the two articles directly cited by Garfinkel, Stallman, and Kapor, see generally Pamela Samuelson, Benson *Revisited: The Case against Patent Protection for Algorithms and Other Computer Program-Related Inventions*, 39 Emory L J 1025 (1990); Pamela Samuelson, *Should Program Algorithms Be Patented?*, 33 Comm ACM 23 (1990).

By 1993, a multidisciplinary group of scholars had issued the Bellagio Declaration, explicitly raising the concern that "[t]he aggressive expansion of intellectual property rights has the potential to inhibit development and future creation by fencing off 'the commons,'"[56] a set of concerns that one of the declaration's coauthors, James Boyle, went on to explore extensively in *Shamans, Software, and Spleens*.[57] Some of the participants in that process were focused on more Ostrom-school concerns, such as Keith Aoki's work on preserving access of farmers to landrace seeds in the teeth of "rationalization" through proprietary seed development,[58] or Rosemary Coombe's research on cultural property of indigenous people whose common property was being extracted by pharmaceutical companies that turned it into private property.[59] But Boyle in particular located the centrality of the aggressive expansion or fencing in of the commons in an understanding of a new moment in economic history. He argued that understanding the dynamic of intellectual property and the commons is the equivalent, for understanding the networked society, of understanding "the legal and social arrangements of wage labor and the institutional framework of capital formation" for "understand[ing] the American economy of the early twentieth century."[60] Boyle further argued that such understanding is critical for a coalition of those who have "greater concern for the public domain [ ] as a resource for future creators and as the raw material for the marketplace of ideas," including reporters concerned about chilling effects on journalism from *The Nation* case (Ford memoirs),[61] "the programmers in the League of Programming Freedom" (the precursor to the Free Software Foundation), rap musicians who wish to sample music, and small software

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56 *The Bellagio Declaration* (Society for Critical Exchange), online at http://www.cwru.edu/affil/sce/BellagioDec.html (visited Sept 15, 2013).

57 James Boyle, *Shamans, Software, and Spleens: Law and the Construction of the Information Society* 174–84 (Harvard 1996).

58 See Keith Aoki, *Neocolonialism, Anticommons Property, and Biopiracy in the (Not-So-Brave) New World Order of International Intellectual Property Protection*, 6 Ind J Global Legal Stud 11, 52–57 (1998).

59 See Rosemary J. Coombe, *Intellectual Property, Human Rights & Sovereignty: New Dilemmas in International Law Posed by the Recognition of Indigenous Knowledge and the Conservation of Biodiversity*, 6 Ind J Global Legal Stud 59, 80–89 (1998).

60 Boyle, *Shamans, Software, and Spleens* at 13 (cited in note 57).

61 *Harper & Row, Publishers, Inc v Nation Enterprises*, 471 US 539 (1985) (holding that *The Nation*'s unauthorized publication of excerpts from President Gerald Ford's not-yet-published memoirs was not a fair use).

companies, among others.[62] In other words, Boyle saw the new understanding of the commons as necessary to define precisely the coalition that would ultimately come together over the first decade of the twenty-first century to challenge efforts to expand intellectual property rights. Contributing to the generalization of the concept of freedom to operate was the fact that proponents of strong patent or copyright began to take the "intellectual property" moniker seriously and make claims about the beneficial effect of "property" institutions in the area of innovation and creativity.[63] Mark Lemley offered an early critique of this propertization movement based on endemic market failures in the economics of improvements in information and innovation and strong positive externalities,[64] and Julie Cohen criticized nascent efforts to apply concepts from physical property to cyberspace as fundamentally misplaced.[65]

Building on the work on the public domain, my own contribution was to expand the claim about the role of commons beyond the public domain in intellectual property to a broader set of resources central to networked society and economy. In work specifically on spectrum commons[66] and intellectual property,[67] I argued that, because of nonrivalry or renewability, commons were a viable alternative to state or private property for a wide set of resources that were critical to the information economy;[68] the primary effect of the choice between commons and property was the industrial organization of the system,[69] in particular, that "commons can cause organizations and individuals who use these resources to organize the way they produce information in

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62 Boyle, *Shamans, Software, and Spleens* at 168 (cited in note 57).

63 See Edmund W. Kitch, *The Nature and Function of the Patent System*, 20 J L & Econ 265, 267–75 (1977).

64 See Mark A. Lemley, *The Economics of Improvement in Intellectual Property Law*, 75 Tex L Rev 989, 1049–57 (1997).

65 See Julie E. Cohen, Lochner *in Cyberspace: The New Economic Orthodoxy of "Rights Management"*, 97 Mich L Rev 462, 466 (1998).

66 See Yochai Benkler, *Overcoming Agoraphobia: Building the Commons of the Digitally Networked Environment*, 11 Harv J L & Tech 287, 359 (1998).

67 See Yochai Benkler, *Free as the Air to Common Use: First Amendment Constraints on Enclosure of the Public Domain*, 74 NYU L Rev 354, 424 (1999).

68 Yochai Benkler, *The Commons as a Neglected Factor of Information Policy* *2 (speech presented at the 26th Annual Telecommunications Research Conference Oct 5, 1998), online at http://www.benkler.org/commons.pdf (visited Sept 15, 2013).

69 See Benkler, 74 NYU L Rev at 400–01 (cited in note 67); Yochai Benkler, *Intellectual Property and the Organization of Information Production* *42–44 (unpublished manuscript, Oct 1999), online at http://www.benkler.org/Ipec99.pdf (visited Sept 15, 2013).

a decentralized pattern."[70] Abstracting away from the particular doctrines or rules through which any given open-access commons was made and rejecting the idea that an absence of rules was definitional, I argued that "commons" referred to "institutional devices that entail government abstention from designating anyone as having primary decision-making power over use of a resource."[71] It was not the absence of any use rules that made a commons, but the absence of asymmetric power to determine the disposition of a resource. This absence of asymmetric power, in turn, provided for a more diverse speech environment,[72] offered more diverse market innovation in wireless equipment,[73] and harnessed the innovation and creativity of radically decentralized actors more generally: "The capacity of thousands to scour a rich universe of existing information resources allows them to identify productive opportunities and the creative individuals who can best use these resources. That capacity is the primary source of increasing productivity gains that peer production offers our economy."[74]

Lawrence Lessig wrapped up this first decade of work on the networked economy commons in 2001 by generalizing it to the Internet as a whole, at its physical, logical, and content layers, and connecting the commons to the core value of avoiding a permissions culture.[75] In other words, commons at every layer of the networked environment meant that no one needed permission to create and express themselves, that no one needed permission to innovate in and with the network, and that as a result creativity, speech, and innovation all depended on a robust commons throughout these resources.[76]

In 2005, Frischmann first began to reconnect the work on the Internet and public domain to the kinds of physical commons with which Rose had begun the conversation.[77] There he first pursued the approach that he now concludes in *Infrastructure*, expanding from Internet and public domain, to roads,

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70 Benkler, *The Commons as a Neglected Factor* at *1 (cited in note 68).

71 Id at *2.

72 See id at *2–3; Benkler, 74 NYU L Rev at 386 (cited in note 67).

73 See Benkler, 11 Harv J L & Tech at 290–92 (cited in note 66).

74 Yochai Benkler, *The Battle over the Institutional Ecosystem in the Digital Environment*, 44 Comm ACM 84, 88 (2001).

75 Lawrence Lessig, *The Future of Ideas: The Fate of the Commons in a Connected World* 147–233 (Random House 2001).

76 See id at 161.

77 See Frischmann, 89 Minn L Rev at 923–28 (cited in note 7).

lakes, and a wider range of infrastructure goods entirely unrelated to the networked information economy (p ix). But before I turn to exploring his argument as it has developed in the new book, I will spend a few paragraphs distinguishing various other usages of the "commons" that are parallel, but not quite part of, either of these two major schools of thought on the commons.

3. Mapping commons studies.

In the fall of 2001, Ostrom first engaged the new legal literature on commons. In the first of several works she co-authored on this tension with Charlotte Hess, Hess and Ostrom focused on Litman's *Public Domain*,[78] Lessig's *Code and the Commons*,[79] and my own *The Commons as a Neglected Factor of Information Production* for critique.[80] Hess and Ostrom's primary critique of our work was that we in the legal academy were too focused on the public domain as the core instance and were unable to answer the question of what is "the commons": "Is it a given right, a nonassigned right, an unclaimed right, an unmanaged resource, or something that should just be there in a democracy?"[81] They then proceeded to lay out the analytic framework that made *Governing the Commons* and the work on common property regimes so successful—an institutionalist method of critiquing the neoclassical model of property.[82] In particular, on the characteristics of the resource set, Hess and Ostrom emphasized the centrality of high subtractability to the definition of common-pool resources and underscored that what these resources

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[78] The quote they referred to was: "In the intellectual property context, the term describes a true commons comprising elements of intellectual property that are ineligible for private ownership. The contents of the public domain may be mined by any member of the public." Litman, 39 Emory L J at 975 (cited in note 46).

[79] Lawrence Lessig, *Code and the Commons* *2 (speech presented at the conference on Media Convergence at Fordham University Law School Feb 9, 1999), online at http://cyber.law.harvard.edu/works/lessig/fordham.pdf (visited Sept 15, 2013) ("The commons: There's a part of our world, here and now, that we all get to enjoy without the permission of any.").

[80] Benkler, *The Commons as a Neglected Factor* at 2 (cited in note 68):

> "The commons" refers to institutional devices that entail government abstention from designating anyone as having primary decision-making power over use of a resource. A commons-based information policy relies on the observation that some resources that serve as inputs for information production and exchange have economic or technological characteristics that make them susceptible to be allocated without requiring that any single organization, regulatory agency, or property owner, clear conflicting uses of the resource.

[81] Hess and Ostrom, 66 L & Contemp Probs at 114 (cited in note 3).

[82] See id at 118–28.

shared with public goods was the difficulty of exclusion, not a nonrival nature.[83] On the characteristics of the institutional regime, they emphasized—as Ostrom had in *Governing the Commons*—the "confusion between open-access and common-property regimes."[84] The combination of these distinct characteristics of common property regimes led Hess and Ostrom to caution that

> analyzing the whole ecosystem of scholarly information is much more tenuous than in *Governing the Commons* . . . . Information . . . often has complex tangible and intangible attributes: fuzzy boundaries, a diverse community of users on local, regional, national, and international levels, and multiple layers of rule-making institutions. . . . *Distributed* digitized information, such as that on the Internet, adds more layers of complexity to the flow. . . . [D]igital information, though subject to congestion, is generally nonsubtractive; thus, the resource flow is not subject to erosion (deterioration) in that same way that physical information artifacts are (books, journals, newspapers, etc.).[85]

To overcome these difficulties, Hess and Ostrom chose to apply their familiar framework to the most "well-behaved" problem associated with information and knowledge: libraries.[86] Libraries are simple for the literature on common-pool resources because they are hard to characterize as problems of information economics. Unlike their knowledge content, copies of books are rival and excludable. Library stacks, reading rooms, and budgets are constrained. These problems were the familiar problems of congestible facilities and subtractable (or rival) goods, meant to be shared by a moderately large and definable set of users, applied near a domain that raises the real challenges to the traditional model of property when applied to innovation, knowledge, culture, and communications. But the basic theoretical challenge remained: at the very heart of the most advanced economies, commons of a form that did not fit the increasingly legitimate version of felicitous commons studies were growing in importance.

Following on this initial assessment, the most comprehensive and thoughtful map of this terrain was Charlotte Hess's

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[83] See id at 120.

[84] Id at 122.

[85] Hess and Ostrom, 66 L & Contemp Probs at 132–34 (cited in note 3).

[86] Id at 134–39.

Mapping the New Commons.[87] Covering over 450 references mostly published between 2000 and 2007, Hess surveyed the literature on commons outside what she calls "traditional commons,"[88] or what I have here described as the Ostrom school. Mostly, the new commons Hess described included knowledge and Internet commons as well as infrastructure, which primarily meant, in that review, spectrum commons and core Internet standards and protocols.[89] Furthermore, specific work on, for example, open-access scientific publications, access to medical innovation and biomedical materials, or cultural commons feature as distinct elements, but these largely fall within a similar concern with enclosure and control, and many share the economic characteristics underscored by the 1990s work on the public domain and the Internet. The primary third school of commons studies one might identify from Hess's review, in addition to the Ostrom school and the open-commons school, is the use of commons to identify a set of problems around the ideas of shared fate and publicly owned resources as a critique of capitalism. Here commons refers to a sense that we are at risk globally of destroying the planet based on a tragedy of the commons, and the work thus evokes both the tragic sense of the commons and a pastoral image of the commons as shared heritage, using it as normative leverage to claim against overdevelopment or breakdown of human social and ecological systems in the face of the logic of growth. David Bollier's work has been central in bridging between this literature and the two other schools.[90] I will not explore this third school here, although Frischmann's book does seek to incorporate that aspect of commons literature by treating lakes and the environment as "infrastructure" alongside roads, electricity systems, and human knowledge (p 227). Addressing that aspect of the commons literature is beyond the scope of this Review, however. It is challenge enough to crystallize the distinction between open commons and the Ostrom school, and to outline the possibility of constructive dialogue between these two schools without expanding further.

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87 Hess, *Mapping the New Commons* at *13 (cited in note 3).

88 Id at *2.

89 Id at *18–19.

90 See generally, for example, David Bollier, *Silent Theft: The Private Plunder of Our Common Wealth* (Taylor & Francis 2003); David Bollier, *Public Assets, Private Profits: Reclaiming the American Commons in an Age of Market Enclosure* (New America Foundation 2001), online at http://www.newamerica.net/files/nafmigration/archive/Pub_File_650_1.pdf (visited Sept 15, 2013).

Finally, within the legal literature there are two terms that incorporate the word "commons" and have become widely used, and these need to be distinguished here from the open-commons school. First, Michael Heller's "anticommons" concept refers to a situation of extreme Coasean inefficiency.[91] Ronald Coase explained that, given transaction costs, markets will fail to move entitlements to their best use; markets move entitlements only to uses whose marginally higher value exceeds present uses by more than the transaction costs associated with shifting to the higher-valued use.[92] That is why it is important for judges to assign rights to their best use or to lower transaction costs: they cannot rely on markets to effect transfers given transaction costs. Heller, observing the bizarre construction of rights in the post-Soviet economies, identified a state in which property rights in critical dependencies lead to stasis.[93] Given sufficient mismatch between the shape of entitlements and the usable packets of resources, and sufficient transaction costs for the recomposition of resources into usable packets, resources will go unused, as opposed to merely inefficiently used.[94] This then became an excellent model by Heller and Rebecca Eisenberg for identifying the problems with patenting of small-scale research tools and gene sequences,[95] and what others, following Carl Shapiro, called "patent thickets."[96]

It is critical to understand that, as a matter of legal theory and institutional design, the implication of identifying anticommons problems is not necessarily the introduction of commons or a common property regime (although it might be). The first and most direct implication is the need to understand the scope and definition of usable units of the resource in question. Then, one may need either to redefine the property rights in question to fit usable units of the covered resource or to define a commons in the resource, depending on whether it is the type of resource that is best governed by commons or property. But if the answer

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91 See Michael A. Heller, *The Tragedy of the Anticommons: Property in the Transition from Marx to Markets*, 111 Harv L Rev 621, 624 (1998).

92 R.H. Coase, *The Problem of Social Cost*, 3 J L & Econ 1, 15–16 (1960).

93 Heller, 111 Harv L Rev at 621 (cited in note 91).

94 Id.

95 See Michael A. Heller and Rebecca S. Eisenberg, *Can Patents Deter Innovation? The Anticommons in Biomedical Research*, 280 Science 698, 699–700 (1998).

96 See Carl Shapiro, *Navigating the Patent Thicket: Cross Licenses, Patent Pools, and Standard Setting*, in Adam B. Jaffe, Josh Lerner, and Scott Stern, eds, 1 *Innovation Policy and the Economy* 119, 120 (MIT 2001).

to a perceived anticommons problem is not obtainable by a redefinition of private property rights around the resource in question, but rather requires instantiation of a commons, like a highway, then the core problem for the resource is not an anticommons problem at all: it is one of misapplying property where commons are the appropriate institutional form. In other words, "anticommons" rather than "lack of commons" is the best description of the diagnosis only if "better-defined property rights," as opposed to a "better-designed commons," is the primary treatment.

The second important use of the term "commons" is Henry Smith's "semicommons."[97] Semicommons, backed out of Smith's study of the open-fields system in England,[98] refers to a situation where the same exact resource is used best for production at different scales.[99] In the case of fields, wheat growing, which was done on private allocations within the open fields, was a small-scale event, while animal grazing was a large-scale event with costs (trampling) and benefits (manure) for wheat growing. A well-functioning semicommons divided the individual tracts such that small-scale production problems were appropriated efficiently, while free riding or defecting in the common uses was hard.[100] Several papers have tried to analyze policy problems directly applicable to the Internet by comparison to semicommons: telecommunications regulation,[101] information production and intellectual property,[102] or the Internet more generally.[103] Of these, the application to intellectual property seems most apt. In particular, it helps explain that debates over the proper scope of intellectual property are never between property and commons, but rather are debates over delineating the boundaries (a) within a semicommons between the private and common aspects (for example, debates over term of coverage, or the definition of fair use), and (b) between where there is a semicommons and where

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97 See Henry E. Smith, *Semicommon Property Rights and Scattering in the Open Fields*, 29 J Legal Stud 131, 131–32 (2000).

98 See id at 134–38.

99 See id at 131–32.

100 See id at 149–51.

101 See Henry E. Smith, *Governing the Tele-semicommons*, 22 Yale J Reg 289, 293 (2005).

102 See Robert A. Heverly, *The Information Semicommons*, 18 Berkeley Tech L J 1127, 1127 (2003); Henry E. Smith, *Intellectual Property as Property: Delineating Entitlements in Information*, 116 Yale L J 1742, 1794 (2007).

103 See James Grimmelmann, *The Internet Is a Semicommons*, 78 Fordham L Rev 2799, 2799–2800 (2010).

there is commons simpliciter (for example, rights in data, status of government publications, and future status of academic publishing straddle the two types of debate).

Given that information goods are nonrival, the exclusion of pure property-like systems is unsurprising. Even the efforts of Hollywood and the recording industry to create an effectively perpetual copyright[104] are an instance of debate about where the boundary within a semicommons is located: none of the industry lobbyists are suggesting that *scènes-à-faire* doctrine be changed to force them to pay owners of standard plot lines a royalty; none are suggesting that Shakespeare's or Dickens's heirs be located so as to facilitate a market in clearances of rights to make new versions. Finally, the application of semicommons to the Internet generally, based on the private ownership of computers and physical connections to an open network, seems to suffer from the same mistake as treating highways as semicommons because they are used in private cars. TCP/IP is at its very core a protocol for symmetric, best-efforts clearance of calls on the resources of the network, free of any calls on the state to prioritize one person's preferences for clearance over the network over another's.[105] It epitomizes a commons. HTML and the Web similarly do so. Indeed, recent efforts by such bastions of socialism as the *Financial Times* to develop an HTML5-based version for the iPhone and remove apps from the App Store are precisely an instance of organizations leveraging the commons aspect of HTML to get out from a property system applied in a platform context that gave Apple the leverage to demand 30 percent of every app-based transaction.[106]

II. THE ARGUMENT OF *INFRASTRUCTURE*

Frischmann approaches the expansion of the scope of commons-based management systems from the perspective of demand-side market failures in a broadly defined class of resources that he defines as "infrastructure" (p 61). He explicitly eschews the vulgar "if infrastructure, then commons" argument (p 60), but he does argue that, for resources that fall into the

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104 See, for example, Sonny Bono Copyright Term Extension Act, Pub L No 105-298, 112 Stat 2827 (1998), codified in various sections of Title 17.

105 See Benkler, 11 Harv J L & Tech at 334 n 207 (cited in note 66).

106 See *FT Pulls App over Customer Data Dispute with Apple*, BBC News (BBC Aug 31, 2011), online at http://www.bbc.co.uk/news/business-14734911 (visited Sept 15, 2013).

definition of infrastructure, commons of various forms often provide a useful institutional solution space to the range of demand-side problems that these resources present for classic property-based, private provisioning (p 93).

In Frischmann's approach, resources are "infrastructural" if they satisfy three characteristics:

> (1) They are resources that "may be consumed nonrivalrously for some appreciable range of demand" (p 61);[107]
>
> (2) They are resources whose demand is primarily as input into downstream productive activities or capital goods (p 61); and
>
> (3) They are used as input into a wide range of goods and services, including, importantly, downstream public goods and "social" goods—by which he means a range of nonmarket goods, like ecosystems or rule of law; merit goods (things a society's normative commitments require that everyone have); social capital; and Charles Taylor's "irreducibly social goods"[108] (p 61).

Frischmann is explicit that these three characteristics are cumulative and that what he calls "infrastructure goods" are solely those that are characterized by all three (p 66). The first, he argues, assures that the insights are limited to resources where the costs of not installing a private property system are relatively low (p 66). The second and third "give rise to an assortment of demand-side market failures associated with externalities, high transaction and information costs, and path dependency" (p 66). About half the book is then dedicated to working out the particular market failures associated with these characteristics, in particular the ways in which aggregate private demand for these goods will fail to express the full social value of these infrastructural resources, and hence markets will fail to provision them adequately.

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[107] What he means by this is actually broader than nonrivalry. He includes resources that are nonscarce over a substantial range of their demand, are congestible over some ranges, are susceptible to clearance by nonproperty models during the period of congestion, and are renewable within a period sufficiently compact to retain both their nonscarce condition and their shareable nature during congestion over the long term, like roads. He calls these "partially (non)rival," an aesthetically odd construct, but one that does not affect the analytic content.

[108] See Charles Taylor, *Philosophical Arguments* 127–45 (Harvard 1995).

A critical element of the argument is that, in these resources, positive externalities are widespread, and mechanisms of internalization are likely to be costly and imperfect (pp 39–41). From Frischmann's perspective, this phenomenon is limited to instances where public and social goods are a significant part of the downstream products using infrastructure inputs, because those are particularly vulnerable to a poor fit between the aggregate welfare they produce and the privately expressed demand for the infrastructure (pp 48–56). By contrast, a road that only leads to a small number of privately owned factories, all of which can calculate and express their private value of access to the road, is not an "infrastructure resource" as he defines it (pp 48–49). While an input into downstream production, and partaking of the demand variability characteristic that Frischmann calls "partial (non)rivalry," (pp 30–32) the downstream users have no difficulty expressing their private welfare through payments to a road owner, and there are no meaningful failures associated with internalization.

A second major element is that "infrastructure" is clearly *not* limited to public and social infrastructure, but includes commercial infrastructure as well. Core examples Frischmann identifies are basic manufacturing processes, like milling or the assembly line, basic agricultural and food production processes, such as irrigation technology or canning, roads, the electric grid, telecommunications networks, and so forth (p 67). However, although these are "infrastructure" based on his definition, he claims that these are not usually candidates for "commons management" on the basis of their function as commercial infrastructure. Instead, Frischmann claims that "[f]or pure commercial infrastructure, competitive output markets should work well and effectively create demand information for the input, and market actors (input suppliers) will process this information and satisfy demand efficiently" (p 68). I will take up this argument in Part III. Suffice it to say that Frischmann himself doesn't really hold a broad version of this basic statement, because he immediately explains that research, even applied commercial research and certainly basic commercial research, has strong positive externalities that cannot, and should not, be internalized (p 78 figure 4.4).

Because of his baseline commitment to focusing on demand-side failures and his claim that commercial infrastructure does not present particular demand expression problems, Frischmann

emphasizes the critical role of public and social goods that depend on infrastructure in justifying the use of commons. Where infrastructure is a necessary input to public and social goods, the demand for these goods, which is not fully expressed in markets, if at all, will not generate sufficient sales whose value can adequately represent demand for the infrastructure inputs (p 74).

The most important element in the argument, to which I return in Part III, is uncertainty and flexibility. Following a behavioral framing, Frischmann discusses these as "biases" (pp 82–86), applied to organizations, to wit, infrastructure providers, who will seek more appropriable gains (as opposed to ignoring externalities-rich applications), "sure bet" optimization, and bias toward optimization to existing applications or downstream uses, rather than to open innovation on the infrastructure. I am not at all convinced that cognitive "bias" is the right way to think about organizational (as opposed to individual) decision making at all, or about these particular kinds of failures, or is even necessary to describe the actions of organizations seeking increased returns to investment, rents, or reduced variance in returns. Whether or not one uses a behavioral framework to make these points, the role of late-binding design, or flexibility of infrastructure to a range of unknown uses, has been central to the analysis of commons in communications and the public domain[109] and is absolutely central to understanding the ubiquity of commons in modern complex economies.

The final piece of the puzzle is Frischmann's argument that infrastructure is often best managed as an open-access commons subject to certain use rules, or at least on the model of an open class of users. Critical to the definition of commons management as he uses it is that the resource is open on "nondiscriminatory terms . . . that do not depend on the users' identity or intended use" (p 92). This does not necessarily require government regulation. Consistent with his view of commercial infrastructure, his focus for government action is on public and social infrastructure. As far as regulating commercial infrastructure, he concludes that "the case for imposing commons on privately-owned commercial infrastructure is limited to well-understood rationales reflected in antitrust and regulatory economic tradi-

[109] The best crystallization of the argument is Lessig, *The Future of Ideas* at 88–89 (cited in note 75).

tions" (p 107). In particular, he emphasizes essential facilities concerns on the antitrust side, and natural monopoly and social policy constraints on the regulatory side (pp 106–07). He puts the weight of his argument for regulatory choices behind public, social, and mixed infrastructures (those that are an input to both commercial and public or social uses). His strong emphasis here is that firms have no particular advantage in measuring or predicting social value, so that for "public, social, and mixed infrastructure, the case for commons management largely turns on the degree of social value uncertainty" (p 113).

This does not mean that he argues that commercial infrastructure is not best managed as a commons, that is, by providing the flow of resources on a nondiscriminatory basis to all comers. Instead, he argues that there is a strong business case that will lead firms operating under uncertainty to adopt commons management of their private infrastructure. He suggests five reasons, some of which are decidedly unpersuasive, while others offer real insight (pp 95–99). First, he states that consumers dislike discrimination, and therefore firms do not generally engage in price discrimination (pp 95–96). Second, he argues that an open, uniform platform may be easier to manage—essentially, that the private transaction costs associated with discrimination among consumers outweigh the private benefits of the infrastructure owners (p 96). These arguments are empirically suspect (that is, we see price discrimination practiced widely in markets, and the cost is managed usually by tiering[110] as opposed to fine-grained discrimination) and theoretically unsatisfying. Commons is an institutional arrangement; it is a legal category; it describes a decision by the state to abstain from throwing its weight behind any single claimant to control the resource. A property owner who chooses to offer goods at the same price to all its customers, but is completely free to do otherwise, is exercising its exclusive property right; it is not creating a "commons" unless it formally abjures that right. Certainly, we see companies releasing their software under free software licenses that *formally* bind them to a "contractually reconstructed" commons model;[111] but treating an at-will decision by a vendor to

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[110] See Dennis L. Weisman and Robert B. Kulick, *Price Discrimination, Two-Sided Markets, and Net Neutrality Regulation*, 13 Tulane J Tech & Intel Prop 81, 86, 94 (2010).

[111] See, for example, J.H. Reichman and Paul F. Uhlir, *A Contractually Reconstructed Research Commons for Scientific Data in a Highly Protectionist Intellectual Property Environment*, 66 L & Contemp Probs 315, 334 n 72 (Winter-Spring 2003) (describing the

offer standard prices to all consumers as an example of a "commons" threatens to make the category meaningless.

The remaining three reasons Frischmann gives are engaging competitors in cooperative codevelopment, engaging users, and maintaining flexibility in the face of uncertainty. These reasons certainly do cohere with the experience of network and high-technology industries. Free and open-source software (FOSS) licensing, for example, enables interconnection or joint development of platform technologies like Linux (p 96); similarly, FOSS licensing or adherence to open, nonproprietary standards facilitates incremental contributions by suppliers and productive users in modular industries (pp 96–97). That is, where downstream innovation increases the total value of the infrastructure, commons management can encourage that downstream effort. Finally, these privately adopted practices maintain flexibility in the face of uncertainty (p 98).

Frischmann moves on in the middle of the book to address what he calls "complications" (pp 115–86). Pricing of nondiscriminatory access in privately owned infrastructure is one problem that he addresses (pp 117–35), and to a limited extent he also addresses provisioning problems (pp 159–86). But the primary move here is an analysis of congestion management, a classic commons problem (pp 136–58). His answers are drawn from the well-known set: expanding capacity or building excess capacity; limiting user-community membership (this is the primary focus, historically, of the Ostrom school);[112] congestion pricing; and use restrictions, such that uses that are more congestion inducing may be limited relative to other uses. All these are introduced against the background of the claim that congestion need not necessarily be eliminated (p 140). Queuing and clearing are complements, and we interchange them everywhere, from the checkout counter at the supermarket to the Internet protocol. Each solution to avoid or clear congestion has its own limitations and costs in contexts, and the core message of Frischmann's treatment is that, wherever a congestion-management approach requires discriminatory treatment by user or usage type, or by congestion pricing, a cost is imposed on uses that is not always susceptible to expression in willingness to pay or in political and social power to shape the use restrictions to permit

standard clause in a National Science Foundation grant encouraging free dissemination of information).

[112] See note 26 and accompanying text.

the operation of the congestion-management approach (pp 155–58). All the reasons that commons may make sense also suggest caution with the various methods of congestion management.

The remainder of the book looks at different forms of infrastructure, from what he calls "traditional" infrastructure, mostly roads (pp 189–210) and telecommunications (pp 211–24), through ideas (pp 256–75) and intellectual property (pp 275–314), all the way to environmental ecosystems (pp 227–52). In the classic division between splitters and lumpers,[113] Frischmann shows himself here to be a lumper par excellence. This tends to obscure what is likely the most important contribution of the book. The ambition to bring all these different types of resources and systems under a single-definition framework of "infrastructure" requires Frischmann to treat genuinely nonrival, classic public goods, like information, knowledge, and culture, as part of the same framework as clearly congestible goods like roads, lake shores, or fisheries. His need to treat genuinely production- and growth-oriented goods, like telecommunications networks or highways, with ecological systems, like lakefronts, in turn pushes him to remain at a level of abstraction that is at odds with the call for highly nuanced, context-specific analysis that marks the Ostrom school, and that is so central to Frischmann's other project with Strandburg and Madison to import the IAD framework into the study of knowledge commons.[114] But more on that in Part IV. For now, it is important to note that Frischmann's theoretical ambition is in tension with his efforts to provide nuanced, context-dependent analysis. He aims to provide an all-encompassing theory of *infrastructure*, rather than *commons*, and to ground that theory in a demand-side economics of public, social, and commercial goods. But his institutional and policy focus remains exclusively on when it makes sense to adopt commons for infrastructure broadly defined.

The focus on infrastructure in the broadest definition, on the demand-side failures, and on the commons-management aspect to the exclusion of provisioning questions hinders the argument in two ways. First, by including in "infrastructure" resources that do not use open commons as their core organizing principle, Frischmann's argument necessarily lacks a crisp

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[113] Gerald Holton, "*Lumpers," "Splitters," and Scientific Progress*, 8 Academic Questions 14, 14–15 (Spring 1995).

[114] Madison, Frischmann, and Strandburg, 95 Cornell L Rev at 678 (cited in note 14).

delineation and exploration of the role, necessity, and management of open commons as a class of institutional interventions. Second, by focusing on commons management as the core policy question, and on outlining demand-side failures alone, Frischmann avoids the questions of how to choose among public, market, and social provisioning of infrastructure. Writing a book on infrastructure that would have challenged the 1990s-minted ideology against public investment and in favor of privatization wherever possible would be a reasonable choice and would require different analyses of the supply side, not solely demand-side factors. Writing a book on commons that challenges the last several decades' "tragedy of the commons" problems and expands on the role commons play in enabling growth in complex modern economies would similarly have been a critical contribution. I still think that it is the most important contribution of this book, and that it is indeed an important contribution. But the ambition to do both dampens the effect.

The difficulty that Frischmann faces because of his emphasis on "infrastructure" as opposed to "commons" is clearest in the chapter on environmental infrastructure (pp 227–52). Here, Frischmann explains why the environment in general, and particular elements in it—a lake, river, or forest—are "infrastructure" as he defines it: a set of resources that are at least partially shareable and whose primary value is as an input to a diverse set of productive actions, not all of which are private goods (pp 227–28). But environmental infrastructures are fundamentally different from the other kinds of infrastructure Frischmann yokes together in the book: roads and telecommunications networks, as well as information, knowledge, culture, and innovation. The environment presents no initial provisioning problems, but is replete with congestion, pollution, and underinvestment in renewal. These call forth a diverse set of institutional approaches, almost none of which are sustainable "open commons." The air was an open commons before emissions regulation; its status as open commons was certainly growth promoting, but with potentially disastrous consequences. Global fisheries were open commons, with disastrous results for various fish stocks.[115] So the environment is the resource set where "commons" are

[115] H. Sterling Burnett, *Ocean Fisheries: Common Heritage or Tragic Commons?* *1 (National Center for Policy Analysis Feb 27, 2007), online at http://www.ncpa.org/pdfs/ba581.pdf (visited Sept 15, 2013).

most often observed as "tragic." And, indeed, Frischmann quite explicitly acknowledges this, arguing that

> the dominant approach in the environmental area appears to be a mixed strategy that regulates some uses and sustains a commons for many others. Environmental infrastructure resources are often sustained through complex institutional arrangements that form something akin to semi-commons property regimes, although often through regulatory regimes rather than pure property regimes (p 248).

In other words, the environment is an area replete with regulation or government management; some private rights—certainly asymmetric entitlements, such as fishing quotas or tradable extraction licenses; many Ostrom-school self-governance arrangements; and relatively little by way of open commons that are nonetheless managed in a sustainable form. If "the environment" is infrastructure no less than innovation and highways, then the "commons" that is useful for infrastructure has to be circumscribed or defined in looser terms than the open commons of the highway or the common carriage regime. It need not be a commons open to an open class of users. And this need to circumscribe the meaning of "commons" in order to expand the meaning of "infrastructure" is a loss.

The focus on this broad definition of commons and on demand-side failures of markets for provisioning the class of resources Frischmann calls infrastructure, in turn, allows him to sidestep the issue of public provisioning. In observing the practical areas the book covers, we see roads and highways (pp 189–210), telecommunications systems (pp 211–26), "intellectual infrastructure," in which Frischmann includes a broad swath of the cultural environment (pp 253–316), and environmental resources (pp 227–52). As among these, there is little serious debate in the world today surrounding the public role regarding investment in roads and highways, although there is with regard to railroads and investment in alternative energy generation capabilities.[116] There is a very live debate over whether the "let the private sector lead" and extensive deregulation of last-mile telecommunications distribution was sensible, and a significant

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[116] See, for example, Paula Berinstein, *Alternative Energy: Facts, Statistics, and Issues* 110 (Oryx 2001).

reemerging paradigm of public investment in Internet infrastructure.[117]

Public investment in basic research is another core policy question, one that has attracted substantial empirical work to quantify the significance of its beneficial spillover effects and contribution to growth.[118] Frischmann's focus on demand-side failures that suggest the high imperfection of classic private property rights to elicit market investment hints at the need for public investment; in some cases it hints at the possibility of social production, but the book is not intended as an answer to the supply question. If a reader picks up *Infrastructure* to find out whether the US government or its municipalities should follow the Australian and New Zealand model of massive national public investment in fiber networks or the Swedish model of municipal investment in these networks, she will find no answer. Nor will she find a way of thinking about whether the federal government should launch a Tennessee Valley Authority–style infrastructure project constructing offshore wind farms along the east coast of the United States. For a book that begins by decrying the crumbling state of America's infrastructures (pp ix–x), quoting a 2009 study that called for $2.2 trillion in public investments in infrastructure over five years,[119] this is a real limitation.

Despite these limitations, *Infrastructure* is an important contribution to our understanding of the role that commons play throughout contemporary, complex, dynamically changing economies. In the remainder of this Review I will try to explore further why commons play that role. Like Frischmann, I will avoid the provisioning question: when provisioning of common infra-

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[117] For an early insight, see Eli Noam, *Public Telecoms 2.0: The Return of the State* Financial Times Tech Hub (Fin Times Apr 25, 2007), online at http://www.ft.com/cms/s/2/9be0342c-f253-11db-a454-000b5df10621.html#axzz2Cnm7xCdR (visited Sept 15, 2013). See also Martin Cave and Ian Martin, *Motives and Means for Public Investment in Nationwide Next Generation Networks*, 34 Telecomm Pol 505, 506–07 (2010); Yochai Benkler, et al, *Next Generation Connectivity: A Review of Broadband Internet Transitions and Policy from around the World* *229–39 (report of the Berkman Center for Internet and Society to the Federal Communications Commission, Feb 2010), online at http://cyber.law.harvard.edu/pubrelease/broadband (visited Sept 15, 2013).

[118] For early work, see Zvi Griliches, *Productivity, R&D, and Basic Research at the Firm Level in the 1970's*, 76 Am Econ Rev 141, 151–53 (1986). For more recent work, see Charles I. Jones, *Sources of U.S. Economic Growth in a World of Ideas*, 92 Am Econ Rev 220, 234 (2002).

[119] American Society of Civil Engineers, *2009 Report Card for America's Infrastructure* 6 (citing a study estimating that $2.2 trillion must be invested in the US infrastructure to bring it up to "good" condition).

structures should be publicly funded, socially provisioned, or market-based, and when payment for use, though subject to symmetric access rules, should be required. Instead, I will try to crystallize the argument for the importance of open commons to complex modern economies, and why the basic idea that growth and development require well-defined property rights sees only half the institutional toolkit. What we have long known in intellectual property, that innovation and creativity require a mix of property and robust, substantial commons,[120] is true more generally for complex modern economies.

III. THE UBIQUITY OF OPEN COMMONS IN MODERN COMPLEX ECONOMIES

A. What Is a Commons?

In their most recent effort to address the wider range of commons, Hess and Ostrom defined commons as "a resource shared by a group of people" that can occur at a wide range of scales and, critically, raises challenges of use, governance, and sustainability that can be characterized as social dilemmas.[121] This definition starts from the resource and the social dilemma, rather than the institutional characteristics of the commons. It is broad and encompassing and reflects the origins of the Ostrom school in careful study of hundreds of highly detailed, context-specific, and diverse institutional arrangements for highly diverse resources. By contrast, the legal literature on commons began by looking at the defining institutional characteristic of commons: symmetric use and access rights to an open class of users—roads and navigable rivers, the public domain, and so forth. That institutional emphasis occurred on the background of negation of a particular, and particularly dominant, institution in market society: property. In the legal literature and the open-commons school, the crisp line between commons and property was the presence of a core institutional characteristic that negated property: symmetry of privileges. The institutional arrangement tracked a model of information and motivation. The defining feature of property is that it centralizes the point at which information and incentives necessary to determine the

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[120] See Carlisle Ford Runge, *Common Property and Collective Action in Economic Development*, 14 World Dev 623, 624 (1986).

[121] Hess and Ostrom, *Introduction: An Overview of the Knowledge Commons* at 4–5 (cited in note 3).

access, use, management, and disposition of a given resource in a single entity by giving that entity asymmetric power to determine who will get to access or use the resource, at what time, and for what purposes.[122] Institutionally, what does the work of centralizing information and incentives is the location, in a discrete entity, of a call on the state to impose its power to support that entity's decision. The defining feature of commons is that there is no such asymmetric power. Instead, the resource is subject to a set of symmetric rules concerning access, use, extraction, and management. The absence of asymmetry removes the focal point for transactions—the owner—as a coordinating mechanism for competing claims; but the symmetry allows diverse users the freedom to operate without transacting, at least the freedom to operate within the symmetric constraints and subject to whatever congestion is characteristic of the resource. Information, as in the case of property, is gathered and processed by diverse actors, but unlike the case of property, it is not then collated in a single decision point; rather, diverse actors act upon information they have or exchange without the need to translate it into a universally understood expression (currency, for example) that compares competing uses and clears them. Similarly, motivations for action are not directly tied to, or measured by, the information and decision mechanism. This allows the motivations, like the information, to be divergent and loosely defined. Open commons with this institutional pattern are ubiquitous in modern economy and society.

Consider a day in the life of a Wall Street trader. She wakes up in her private-property apartment (whatever complications co-ops and condos present are outweighed by the core private-property nature of the apartment). She gets out of her private-property bed, and goes into her proprietary bathroom. But then she turns on the light. The electricity is provided by either a private company or a publicly owned utility; whether the company is privately or publicly owned, public utility law prevents it from refusing service to our trader unless she pays a higher amount than do her less wealthy neighbors.[123] If she wants to make toast, the company has no right to prevent her from connecting any toaster she wishes or to advantage her over her neighbors, for a fee, as long as the equipment complies with symmetrically

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[122] Benkler, *The Commons as a Neglected Factor* at 12 (cited in note 67).

[123] See NY Pub Serv Law § 65 (prohibiting price discrimination in the provision of electricity).

imposed safety laws and technical standards. Even after electricity-market deregulation, distribution to homes continues to include a provider of first and last resort—the utility—whose terms of service are regulated and symmetrically available to all. The electric utility cannot offer tiered service to some who are willing to pay more while throttling back use and creating brownouts for those not willing to pay more.[124] While usage metering certainly introduces a market mechanism of sorts to regulate consumption, the critical tell is that even under conditions of extreme congestion we do not permit rolling brownouts based on willingness and ability to pay. The utility has the right to refuse service to nonpaying customers. But the rates and use privileges to connect are not within its property right. That right is constrained to require the company to offer to all comers symmetric privileges of access and use subject to set rates and public standards of connecting equipment to the grid.

Our trader turns on the tap in her sink, and the water that flows is also a commons. The same applies to the sewage system she uses as the water leaves the sink. She uses private property for her toothbrush and soap, her refrigerator, and breakfast. Then she walks out of her door; if she lives in Tribeca and walks, she will use the commons that is the sidewalk. If she hops in a taxi, that private business will use the commons called the street and be regulated as a common carrier.[125] The freedom to operate of the commons assures that she has not only a yellow cab, but can also call any one of a wide range of private carriers, all of whom use the commons to take her from point A to point B without needing to transact to receive permission from an owner of the streets. If she lived in Connecticut and drove in, she would be using I-95 or any of many highways and parkways, all of which are commons, despite the theoretically and occasionally attempted alternatives: private turnpikes, bridges, and ferries. She might take the subway or commuter rail. Again, each is a publicly provisioned, commons-managed system.

As she walks into her office building, she relies on its private property for a place to work. She then turns on her private-property computer. Like her refrigerator at home, this computer, or at least many of its components, was likely imported over an

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[124] See NY Pub Serv Law § 65 (prohibiting electric companies from granting unreasonable preferences to particular individuals).

[125] See NY Gen Mun Law § 181 (authorizing municipal officers and boards to regulate the registration and licensing of taxicabs).

ocean whose shipping lanes are commons, shipped in a container whose standard size reduced its cost, and is an international commons managed by an international standards-setting organization,[126] and was brought through the Panama Canal, which is required by international treaty to allow all peaceful shipping without discrimination,[127] and denies to the Canal Authority the rights to exclude or manage passage, or to alienate its powers.[128] She might read a proprietary news service, but that news service likely relied in part on facts collected elsewhere or data generated by the government. For example, she might wait for the next monthly jobs reports; these facts are in the public domain and governed as commons, and the newsletter harvests from the commons and bundles into a private product.

If she uses the Internet, our trader may use a private connection or a connection subject to common-carriage requirements. Common carriage, in turn, is a set of legal arrangements that assures that a private owner that provisions goods subject to this regime will make them available without discrimination. In other words, while it is a property regime, it is limited precisely along the dimension of asymmetric exclusion. It functions as an open commons, not as a club good, and certainly not as a private good. This is true everywhere outside the United States.[129] In the United States it was certainly true for Digital Subscriber Line (DSL) services prior to 2005, and likely true of

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[126] See generally International Organization for Standardization, *Standards*, online at http://www.iso.org/iso/home/standards.htm (visited Sept 15, 2013).

[127] Treaty Concerning the Permanent Neutrality and Operation of the Panama Canal, 33 UST 11, TIAS No 10029 (1977).

[128] See *Organic Law of the Panama Canal Authority* (Autoridad del Canal de Panamá 1997), online at http://www.pancanal.com/eng/legal/law/index.html (visited Sept 15, 2013), translating Ley Orgánica de la Autoridad de Panamá, online at http://www.pancanal.com/esp/legal/law/contents.html (visited Sept 15, 2013). Article 3 bars all rights of alienation ("The Canal constitutes an inalienable patrimony of the Panamanian nation; therefore, it may not be sold, assigned, mortgaged, or otherwise encumbered or transferred."). Article 5 requires nondiscriminatory access:

> The fundamental objective of the functions attributable to the Authority is that the Canal always remain open to the peaceful and uninterrupted transit of vessels from all nations of the world, without discrimination, in accordance with the conditions and requirements established in the National Constitution, international treaties, this Law, and the Regulations. Because of the nature of the highly essential international public service provided by the Canal, its operation shall not be interrupted for any reason whatsoever.

[129] See Benkler, et al, *Next Generation Connectivity* at *229–39 (cited in note 117) (describing foreign investments in publicly accessible communications networks).

cable broadband as well.[130] Since 2005, debates over net neutrality have muddied these waters somewhat on the regulatory front.[131] But the nature of the service has not changed yet, and its primary locus now concerns "managed services" as proposed by primarily the wireless data providers for their particular form of Internet service.[132] If our trader is using a laptop, chances are it is connected to a WiFi network, and WiFi is an open commons subject to minimal symmetric-use constraints and a family of standards shepherded by a professional association. The Internet itself, riding on top of the wires or wireless, is a commons, as is the Web. If she accesses any website online, the probability is roughly 3:1 that the Web server software is an open-access commons governed by a FOSS license.[133] Market prices she needs to know are in the commons, although her employer likely pays for privileged early access to the information, and so for an economically relevant instant they are a proprietary club good and available only to those who buy access. In this regard membership in the stock exchange historically provided instantaneous access to market data on a club-good model, using the legal right to exclude nonmembers from the privately owned premises of the exchange as a way of excluding them from the real target—the market prices—which are, as a matter of law, a commons. And so the day goes on. If she makes trades, these depend on the legal system, which defines contract and property rights and promises to enforce them. The legal system is available to all on nondiscriminatory terms and no person has

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[130] The status of broadband providers was hotly contested between 2000 and 2005. The most authoritative court of appeals case suggested that broadband consisted of a telecommunications service, which was common carriage, and an information service, which was not. See *AT&T Corp v City of Portland*, 216 F3d 871, 879 (9th Cir 2000). Justice Antonin Scalia wrote that any other interpretation was not only wrong, but impermissible. *National Cable & Telecommunications Association v Brand X Internet Services*, 545 US 967, 1005 (2005) (Scalia dissenting). The Federal Communications Commission nonetheless decided to treat broadband provisioning to the home as an information service, not telecommunications service, and the majority of the Supreme Court held that decision to have been legally permissible, if not obviously correct. Id at 1000–03 (majority).

[131] See generally Barbara van Schewick, *Internet Architecture and Innovation* (MIT 2010).

[132] *In the Matter of Preserving the Open Internet Broadband Industry Practices*, 25 FCCR 17905, 17951–58 (2010).

[133] Apache's most recent market share is ~62 percent; nginx's is ~16 percent; the license used by Google, at 1.5 percent, is unclear. W3Techs, *Usage of Web Servers for Websites* (World Wide Web Technology Surveys May 14, 2013), online at http://w3techs.com/technologies/overview/web_server/all (visited Sept 15, 2013) (updating the percentage of websites using various servers on a daily basis).

the right to exclude anyone else from using it. It is a publicly provisioned commons.

In personal and commercial life, property is ubiquitous and highly visible to us. What is less visible is that this property system is suspended in commons that undergird and are interpolated throughout the proprietary system elements. Perhaps there is a libertarian utopia in which all these functions are subject purely to a proprietary regime. But no country in the world, whether it professes to be capitalist or socialist, functions purely on property or purely on commons.

B. Why Are Commons So Common?

1. Microefficiency under uncertainty and change given imperfect systems of action.

a) Commons and property-based markets. Commons and property trade off freedom to operate for security in holdings and power to appropriate. Imagine that John wants to organize a picnic with his friends. He can rely on a commons or on property. Imagine that John has a small backyard in a private home he owns or rents; he can invite people to his backyard. In this case, we can say that he invested in buying (or renting) secure (for a period) access to the capacity to invite up to fifteen people to an outdoor event at his home. He could also invite them to meet in the park. In that case, he runs the risk of not finding exactly the right spot he wants, or of congestion if it is a beautiful sunny day in Sheep Meadow in Central Park. But he gets the benefit of being able to invite thirty or fifty friends, if that's what he wants. He does not have the security of property holdings, but he does have a greater freedom of action with regard to the size of the lawn he can use and therefore the size of the social network he can engage in this form. Because the park is large and open for all to use, he can be fairly certain that there will be enough room, although he may be uncertain as to its precise quality relative to his yard. If he wants to issue an open invitation for friends of friends to come as well, the probability that such space will be available in the park, compared to the certainty of an available, but potentially cramped space in his backyard, begins to make the freedom to operate (in this case to expand the amount of space used as needed) of the park more appealing.

If he were planning to charge admission, then the loss of power to appropriate by excluding nonpaying participants would outweigh the benefits of flexibility. There, he might choose to expand capacity by renting space from a private party that owns a larger garden. But here again, he runs the risk of either overinvesting or underinvesting relative to the actual number of attendees, which requires that he limit invitations, require clearer RSVPs, and so on to avoid overcrowding or unnecessarily expensive overprovisioning. He also runs into transaction costs that may well make contracting too expensive to justify the transaction to begin with. Once he invests and invites people to a private, precleared, secure proprietary location, expanding or contracting capacity through market exchanges, and moving people to the new space, is likely to be difficult. It is trivial in the park. Note that in an ideal market, where square feet of yard are perfectly fluid and transactions costless, the market would seamlessly replicate the freedom to operate that the commons offers, avoiding the risk of congestion. But the real world is no ideal market; and in the real world—with units of goods and services delivered in noncontinuous packages, with transaction and information costs—the property approach trades off some freedom to operate for certainty and the power to appropriate, while the commons offers the inverse values.

In a highly uncertain, changing environment, with needs and plans that call for continuously updating the required resources, the freedom to operate provided by commons has important, valuable attributes relative to the security of holdings and the power to appropriate of property. This tradeoff is far from hypothetical or limited to parties in the park. When presented with major spikes in its network after introduction of the iPhone, AT&T had major congestion problems with its mobile data network.[134] It could have gone to the secondary spectrum markets set up by the Federal Communications Commission (FCC) a few years earlier,[135] where it could have leased the additional capacity in a spot market.[136] It did not. Instead, it

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[134] See Benkler, 26 Harv J L & Tech at 89 (cited in note 32).

[135] See id at 101.

[136] See Eli Noam, *Spectrum Auctions: Yesterday's Heresy, Today's Orthodoxy, Tomorrow's Anachronism. Taking the Next Step to Open Spectrum Access*, 41 J L & Econ 765, 779 (1998). Noam's vision of a spot market in spectrum, replacing auctions of stable long-term property rights, is most closely implemented by Spectrum Bridge. See Spectrum Bridge *The Secondary Spectrum Market: A Licensing & Leasing Primer* *2 (Sept

combined a long-term proprietary strategy—seeking to purchase licenses from Qualcomm[137]—with a short-term, more dynamic solution that was based on the commons. AT&T invested in WiFi hotspots and encouraged users to off-load traffic to their home and public WiFi spots.[138] SFR in France, the second-largest mobile provider and third-largest home broadband provider,[139] went one further and harnessed all of its home broadband subscribers—about 22 percent of the French market[140]—to become WiFi load-balancing points for all their mobile data subscribers.[141] WiFi off-loading by carriers has become the norm, carrying anywhere from 35 percent to 65 percent of mobile data.[142] The dramatic rate of increase in required data carrying capacity meant that carriers found the commons—WiFi—a more flexible and responsive resource-management strategy for spectrum than secondary markets, which are the closest thing to straight property in spectrum that the FCC has ever developed. Note that carriers do not directly appropriate data carried over WiFi. They charge mobile users based on usage, but usage over WiFi connections does not count toward monthly caps and overage charges. Despite the lack of the power to appropriate data transferred over WiFi connections, the benefits of flexible deployment and network growth outweighed a more slow-moving, expensive, property-based spectrum approach.

The more diverse and uncertain the needs and plans of users—consumers or producers—are, the more attractive the freedom of action associated with having a resource in the commons is to these users. We can conceptualize it as the commons having a private option value to private users (distinct from its welfare effects), whose price is (a) the reduced certainty of availability of a stated quantity of the resource as is available in markets, itself a function of how perfect or imperfect the relevant market is, and how susceptible to failure; (b) the lost appropriation opportunity from not having the resource controlled in a proprietary form; (c) the cost differential between the desired use in the

2008), online at http://spectrumbridge.com/Libraries/White_Papers/The_Secondary_Spectrum_Market_A_Licensing_Leasing_Primer.sflb.ashx (visited Sept 15, 2013).

137 See Benkler, 26 Harv J L & Tech at 101 (cited in note 32).

138 See id at 101–02.

139 See id at 104.

140 Benkler, et al, *Next Generation Connectivity* at *77 (cited in note 117).

141 Benkler, 26 Harv J L & Tech at 104 (cited in note 32).

142 See id at 103. The scale and scope of use, rather than the precise numbers, are what is important for purposes of this Review.

market, given its imperfections (for example, market power over essential facilities) and the cost of using the commons; and (d) the risk that the commons will be congested. The greater the background uncertainty as to the required quantity or quality of the resource and the market imperfections, the higher the option value—that is, the more of the benefits of property an agent would be willing to forgo in exchange for the greater flexibility offered by commons. The symmetric constraints coupled with a general privilege to use the resource under these constraints mean that the need for transactions at the margin is eliminated, and with it transaction-cost barriers: strategic behavior of platform or essential-facilities owners, imperfect information with its widespread risk of unmatched offer-ask differences, and so forth.

Where the level of uncertainty is such that freedom of action (to adapt to changed circumstances) is an important desideratum—in some cases more so than security in holdings (whose value and utility are part of the uncertainty) and power to appropriate outputs directly through exclusion (whose coming into being is part of the uncertainty)—we need, and find ubiquitously around us, both commons and property. On this argument, with perfectly frictionless markets under perfect information, we wouldn't need commons. But this is no more relevant than saying that with perfectly selfless individuals under perfect information and frictionless social exchange we wouldn't need property. Given imperfect markets, imperfect information, diversely motivated individuals, and imperfect systems of social cooperation and exchange, some mix of property and commons is necessary for reasonable planning and pursuit of goals. This is from the *private-returns* perspective, setting aside collective goals like efficiency and growth, much less democracy or a richly expressive culture. From an individual agent's perspective, having a mix of resources—some commons, some property—will increase his or her utility over time, given imperfect markets, persistent uncertainty, and change.

b) Imperfect systems all the way down. This basic trade-off between property and commons is then replicated in the trade-off between commons and state-administered resource systems, where the desired action must be translated into a call on the necessary resources through an administrative process. Similarly, it is replicated in the trade-off between an open commons and a "social-community-governed" resource that needs to

deal with making calls on a resource through the socially acceptable challenge ("Dad, can I borrow the car Friday . . ."). We act through systems that provide us certain affordances and constraints that allow us to predict what resources will be available to us, under what circumstances, and what consequences are likely to follow from various actions we take. None of these systems is perfect (including, certainly, social coordination of commons); we therefore find our societies using a mix of all of them.

Commons are a partial solution to a decision problem we face as individuals, all of whose available systems of action are imperfect. For any given state of the world, we as human beings have a problem of deciding what to do: which set of resources to apply to which set of processes, in order to obtain which set of outcomes, through which system of action. One way to abstract this decision problem is that we can rely on one or any combination of four families of systems: two hierarchical systems, government and firms; and two distributed systems, markets and social interactions. Our actual behaviors and outcomes will be a function of our actions within these four systems and the combined outcome of those behaviors. Each system incorporates its own imperfections, its own error term if you will, such that our behaviors and outcomes reflect a function of these four systems and their cumulative errors. The error term combines information, decision, and execution. Each system has *information* failures: in acquisition, formalization, and processing of information about the state of the world in which we are considering action in terms comprehensible within that system. Each has *decision* errors in the processes it uses to convert the information into a prescription for action within the system. And each exhibits *execution* errors in the transformation of the prescription into action, and the action into outcome.

At a broad level of abstraction, hierarchies, both governments and firms, are better at planning, control, and management of relatively known sets of resources, people, processes, and outcomes. The freedom to operate embodied in commons is better at exploration, experimentation, rapid deployment, and adaptation to new information and experimentally observed improvements, but weaker at providing security in holdings and direct appropriation of the benefits of the action through control over the resources necessary to effect it. Markets, in turn, because of transaction costs and because of information failures

associated with formalization of competing options into a price-cleared comparative framework, fill a middle niche between firms or governments and commons. They permit more security and planning for predictable conditions at the expense of some flexibility and adaptability for unpredictable conditions. This stylized comparison is, of course, too simple. Experimental governmental forms, small entrepreneurial firms, and internal experimental processes within larger firms seek to retain the advantages of these hierarchical forms while improving on experimentation and adaptation; self-governance mechanisms within commons-based practices, such as free-software development or Wikipedia, seek to improve on the management and appropriation limitations without losing flexibility and openness; and market mechanisms incorporate trust, long-term cooperation, and extensive communication to overcome some of the lossiness[143] associated with converting complex real-world values into discrete prices.

By comparison to open commons in complex modern economies, limited common property regimes explored by the traditional Ostrom school cannot offer the same flexibility that open commons do. Indeed, the first three decades of studies in the Ostrom school were heavily focused on long-standing, stable arrangements that developed over time to embody highly refined local knowledge of the conditions of the resource system they governed.[144] What makes open-access commons so flexible is that no one need agree on anything with anyone else about the disposition of the resource, as long as they comply with a limited number of symmetrically applied rules (for example, speed limit, lane shifts, seatbelts; maximum power limits in spectrum; voltage and wattage restrictions in power). CPRs provide governance structures that are not based on the state, but they often define extraction and use rights quite clearly and provide mechanisms for revising the allocations or use rights, sometimes unilaterally and sometimes by agreement.[145] But their relative benefit is in capturing local knowledge that is, by definition, partly tacit and hard to abstract for incorporation into a state-managerial or property-market model, embodying that body of local knowledge in a stable, sustainable resource utilization

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[143] Richard Mayr, *Undecidable Problems in Unreliable Computations*, 297 Theoretical Computer Sci 337, 337 (2003).

[144] See Ostrom, *Governing the Commons* at 58–102 (cited in note 13).

[145] See id at 79–81.

system, and embedding it in a motivational matrix rich in social motivations, as well as material self-interest. While these systems generally include conflict-resolution systems and mechanisms for reorienting the resource and revising the respective rights, these are not systematically more flexible than just straight property or administrative fiat.

Recognizing this difference between open commons on the one hand, and property, administrative management (whether state based or firm based), and CPRs on the other, focuses the value of commons in the characteristics of information and knowledge. The world is complex, messy, and uncertain. It resists abstraction. That is why tacit knowledge is so critical and so sticky. "We know more than we can tell"[146] because even our own mental processes require abstraction if we are to communicate them in terms others can understand. In order to reallocate a resource from one exclusive use to another, it is necessary to translate the comparative uses into some commensurable abstraction: a price, a value cognizable in the administrative system, or a claim on a common pool or social resource stated in terms cognizable by the social system. Open commons avoid that necessity to abstract and translate because uses are not exclusive. It is sufficient for an individual to decide to act, within the constraints of the symmetric access and use rules, without fully expressing the value expected from the contemplated action. The more these rules confine the uses, the less valuable the commons for this purpose. The more abstract, minimally constraining, and general these constraints are, the more valuable the freedom to operate can be. That is why commons with highly abstract and general rules—such as TCP/IP for the Internet, simple power limits for WiFi, compatibility standards for electricity, or speed limits and safety requirements for roads without substantial emphasis on particular uses—implementations, or dedicated channels have proved so productive.

2. Macroeffects of open commons.

From Rose's *Comedy of the Commons* to Frischmann's *Infrastructure*, and through the literature on the public domain, a central claim on behalf of commons is their contribution to positive spillovers in activities that have demand-side increasing returns to scale and scope. As Rose argued, roads and navigable-waters

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[146] See Michael Polanyi, *The Tacit Dimension* 4 (Chicago 1966).

doctrines developed to support open commons as trade began to expand, and in turn the open access to these arteries of trade fed back into increasing levels of trade that used these arteries as transportation inputs.[147] Autarky does not need open roads; free trade does. So too with the very act of trading, or access to ports. The abandonment of exclusive monopolies on trade with certain colonies, or in certain commodities, was a shift in the institutional design of trade to an open commons (in the sense a shift from asymmetric power to control a resource, an exclusive monopoly conveyed as a royal favor or auctioned to the highest bidder, to an institutional system in which anyone could buy and sell traded commodities under symmetrically imposed port tariffs, for example). These physical commons share this characteristic with intangible commons, like open standards. If shipping container standards were proprietary, in the sense that there was an owner of the standard with whom one would have to negotiate in order to use a standard-size container to ship goods around the world, from ship to tractor trailer or train, we would have the transaction costs, strategic behavior, and drag on trade that we see today debated in the question of patents on standards.[148] Innovation obviously does not grind to a halt, but the drag is well studied.[149] The centrality of robust open commons to growth became clearer as we came to see data and information, innovation, and knowledge as ever more central to growth and development, and innovation and growth, in turn, as the core contributor to welfare over time.

Frischmann's *Infrastructure* locates these spillovers at the heart of his case for infrastructure in general and commons management approaches in particular (p 94). Moreover, an important contribution of his particular analysis is to identify that most infrastructures we care about involve mixed downstream uses: commercial, public, and social. As a result, the positive externalities and spillovers are larger and less tractable, in the sense that they cannot effectively be internalized in the classic economic sense without altering or ignoring the social- and public-goods aspects of the infrastructure (pp 108–14).

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[147] See Rose, 53 U Chi L Rev at 767–70 (cited in note 4).

[148] See Pamela Samuelson, *Are Patents on Interfaces Impeding Interoperability?*, 93 Minn L Rev 1943, 1965–69 (2009).

[149] See id at 1969–2003.

3. Commons, uncertainty, and an open society.

If all systems we inhabit—governments and firms, markets and social relations—are imperfect, if all incorporate error as systems of action, and uncertainty is high, commons offer a feedback and correction mechanism for political action as well as for material and intellectual production. In the face of persistent uncertainty, freedom of action in the commons provides room for experimentation not only in productive, material, and intellectual innovation, but in social relations and political action.

The role of commons in political action is most directly visible. To the extent that action through and on political systems requires access to resources—to frame the state of the world and options for collective action, to communicate these views and options, to mobilize for influence over the institutions of the state—open-access commons in a resource base sufficient to participate in that public process expands the range of potential participants. In particular, it allows views to emerge that are insufficiently widespread to garner attention in mass-media markets, and people who are dispersed to collectively mobilize. The debate over Internet and democracy is the current locus of this debate, and I will not rehearse it here.[150]

But the necessary imperfection of all systems—hierarchical (both governments and firms) and distributed (both price based and social)—means that extant systems will always constrain action and implement erroneous choices. Given persistent uncertainty, exploration, experimentation, and adaptation are a necessary source of collective learning and common intelligence for these inherently fallible systems. We have long thought that more or less free markets enable freedom to operate, and are therefore an important corrective to imperfect government decision and conservative or repressive social practices and norms.[151] But more or less free and open commons are similarly an

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[150] For competing views, see Yochai Benkler, *The Wealth of Networks: How Social Production Transforms Markets and Freedom* 176–80, 212–15 (Yale 2006) (arguing that the public sphere created by the Internet democratizes to a greater extent than does traditional mass media); Matthew Hindman, *The Myth of Digital Democracy* 11–12 (Princeton 2009) (asserting that the purported democratizing effect of the Internet is overstated); Cass R. Sunstein, *Republic.com 2.0* 5–12 (Princeton 2007) (warning against the dangers of consumers' increased abilities to "filter" what they are exposed to as a result of emerging technologies).

[151] See Viktor V. Vanberg, *Markets and Regulation: On the Contrast between Free-Market Liberalism and Constitutional Liberalism*, 10 Const Political Economy 219, 221–23 (1999).

important corrective, both to persistently imperfect markets and to the errors of more or less well-functioning markets that, by their nature, drive action toward those behaviors and outcomes that can be translated into exchangeable market value.[152] A core common infrastructure, a set of core resources necessary for action that are available to all for action and are not themselves market cleared, offer a freedom of action that is orthogonal to the freedom of action that a well-functioning market offers. Each has different affordances[153] and constraints. Each permits different kinds of exploration and experimentation. And therefore each is part of the value of an open society as a learning system in the face of persistent uncertainty and constant change.

IV. OPEN COMMONS, THE OSTROM SCHOOL, AND INSTITUTIONAL ANALYSIS OF PERSISTENTLY IMPERFECT, LOOSELY COUPLED SYSTEMS

The critical insight of Ostrom's IAD framework was that human action occurs in discrete arenas with diverse and historically contingent characteristics and actors, whose own interactions were diverse, contingent, and recursive with the physical environment and social practices.[154] Understanding success and failure of these systems required a structured analysis that took local contingencies into account and was capacious enough to accommodate many and diverse institutional solutions to matters of provisioning, allocation, use, and sustainability. This approach then provides an alternative to efforts to generalize across systems and to standardize responses to problems of production in terms of either property and well-functioning markets, or state and well-managed administration. For this diversity to persist, one must assume that different subsystems, while possibly interconnected—as through markets or jurisdictions—retain sufficient internal coherence and independence from each other that their particular arrangement of resources,

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[152] For a particularly compelling and new analysis of one class of such errors, see generally Amy Kapczynski and Talha Syed, *The Continuum of Excludability and the Limits of Patents*, 122 Yale L J 1900 (explaining how diverse limits on excludability systematically bias investment in innovation toward more excludable innovations as a distinct failure, over and above errors associated with nonrivalry, of patent systems).

[153] See Yochai Benkler, *Networks of Power, Degrees of Freedom*, 5 Intl J Comm 721, 724 (2011).

[154] For a recent synthesis and overview of the theory, see Elinor Ostrom and Charlotte Hess, *A Framework for Analyzing the Knowledge Commons*, in Charlotte Hess and Elinor Ostrom, eds, *Understanding Knowledge as a Commons* 41, 42–43 (cited in note 3).

practices, institutions, and agents is the operative determinant of behaviors and outcomes in that subsystem.[155] It suggests a rejection of only the first half of the Anna Karenina principle: while indeed "every unhappy family is unhappy in its own way," it is not at all the case that "[h]appy families are all alike."[156]

When considering the ubiquity of commons in complex modern economies, the critical observation is that provisioning and governance do not always go hand in hand, and the particular form of decoupling is achieved differently for different shared resources. Sometimes, provisioning and governance are combined. Highways and municipally owned public utilities are examples of commons that are provisioned by government organs and institutionally governed by government organs, with rules that leave significant freedom to operate and are then further coordinated locally and dynamically through social norms and simple coordination. Dams in the *zanjeras* that Ostrom described are provisioned socially and locally and governed by social norms and practices of the same community.[157] And so on. But provisioning and governance are not necessarily linked. WiFi devices are provisioned by private markets in devices, subject to governance that is a composite of background rules set by the FCC (government) and standards set by the Institute of Electrical and Electronics Engineers (IEEE), a professional association that is neither a market organization nor the state. Publicly funded research is often publicly provisioned (in the funding aspect) but socially governed by a peer-review process relating to both funding decisions and publication, such that the funding agency does not get to decide what research specifically to fund or publish.[158] Table 1 sketches the various possible combinations, and fills in those we observe, while marking those that necessarily have a null value. The critical point here is the organizational and institutional diversity for the diverse contexts in which resources are managed as commons. The synthesis between the Ostrom school and the open-commons school emerges

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155 This is very much the assumption underlying much of the work in systems theory. See Niklas Luhmann, *The Differentiation of Society* 213–17 (Columbia 1982) (Stephen Holmes and Charles Larmore, trans).

156 Leo Tolstoy, *Anna Karenina* 3 (Random House 1939) (Constance Garnett, trans).

157 See Ostrom, *Governing the Commons* at 82–88 (cited in note 13) (discussing the *zanjera* irrigation communities of the Philippines as an enduring limited community property regime).

158 See Barry Bozeman and Monica Gaughan, *Impacts of Grants and Contracts on Academic Researchers' Interactions with Industry*, 36 Rsrch Pol 694, 704 (2007).

most clearly when we acknowledge that context sensitivity, understanding the resource set and the user set, and how these relate to the particular problems of provisioning and sustainability is precisely the core insight of the IAD approach that the Ostrom school developed and adopted. The trick, or difficulty, in transposing that framework to open commons is that we need to begin to see how subsets of users or actors who do not make up the whole of the user community begin to take over governance roles, and how these, in turn, manage their relationship with the open class of users.

TABLE 1. COMMONS-BASED/OPEN CLASS SYMMETRIC ACCESS AND USE AND PROPERTY-BASED/EXCLUSION GOVERNANCE MODELS ORGANIZED BY MODE OF PROVISIONING

Governance Provisioning	State Regulation	Property and Contract	Social-Cultural Norms	No Constraint
State: Tax, Bonds, Fees	Highways; public utilities; water; mass transit	Null (if universal symmetric access right, then law, not contract, allocates)	Peer review for publicly funded science not patented; parks; city squares; sidewalks	Lighthouses; government data: weather, labor/GDP measurements
	Military bases; food stamps	Government contracts	Publicly funded science that results in patents	Null
Markets: Direct payment, Indirect appropriation	Common carriers; "private" public utilities; unlicensed wireless bands	Broadcast reception (provision in market, but equal privilege to use); GPL/BSD software by firms (for example, Android)	Street performers; online musicians; voluntary compliance systems	Cultural materials & innovation originally commercial now in the public domain
	Automobile safety standards; zoning	Hot dogs; homes; personal computers; IP goods in coverage	Effort in high commitment organizations	Null

Governance Provisioning	State Regulation	Property and Contract	Social-Cultural Norms	No Constraint
Social: Labor and goods, Donations	Solid organ donations	Contractually reconstructed commons; BSD, GPL? CC-BY; CC-SA?; CC-NC	CPRs inside, if need provisioning: for example a dam; von Hippel innovation; Wikipedia editing; much CBPP; GalaxyZoo; Foldit; culturally constructed commons	TCP/IP; the web; WiFi standards; much CBPP outputs; Wikipedia reading
	Health regulation applied to church day care	Enrollment in socially provisioned services	CPRs on the outside; Alicante irrigation system	Null
Nature	Pollution controls; national parks; fisheries	Privately created open nature preserves	CPRs that require allocation: for example, pastures	Air inhalation; Open Ocean transit
	Tradeable permits	Private recreation parks: for example, hunting lodges	CPRs from the outside	Null

The table is based on a more or less standard set of four major provisioning systems—government, market, social, and natural—and four major governance approaches: state, property and contract, social norms, and no constraint. Each cell is divided into two: a light-gray shaded subcell where access to the resource is available to an open class on nondiscriminatory terms and exclusion is eschewed, and a black-shaded subcell where asymmetric exclusion is the organizing principle. The traditional two antipodes (market, state) are represented by the categories of market-provisioned, property- and contract-governed, asymmetric exclusivity subcell (hot dogs, homes, and so on), and the state-provisioned, state-regulated, asymmetric exclusivity subcell (military bases, food stamps). Classic public goods are represented in the state-provisioning, no constraint cell (lighthouses).

The dominant modes of commons that serve as the foundation of commercial, industrial economies fall in the state- and market-provisioning cells, in the nonexclusivity subcells, whether subject to state regulation (highways, public utilities, mass transit for state-provisioned, and common carriers, privately held utilities, or unlicensed wireless bands), or no constraint (open government data, or formerly IP protected materials now in the public domain). The more exotic phenomena that have developed in networked society—free software, both commercial and purely socially produced—occupy the subcells of social provisioning, mostly with no asymmetric exclusivity, while many of the CPRs occupy both the symmetric nonexclusivity (for uses within the CPR) and asymmetric exclusivity (for the relations between insiders and outsiders in CPRs) subcells of social norms-organized, socially produced goods.

What I try to capture in this table is the range and diversity of combinations of practices and institutions surrounding provisioning and governance of the core goods and services in complex modern economies. A longer term project would require an assessment of the relative contributions of each of these classes of outputs to human welfare over time, one that would include the relative contribution of innovation, and within it, of commons-based as opposed to proprietary-exclusive strategies to the rate and direction of innovation. Early efforts by Eric von Hippel and others, for example, just to measure the relative contribution of user innovation, and work comparing the value of WiFi to cellular wireless systems,[159] suggest that the contribution of commons-based approaches is substantial.[160] For now all that I am seeking to establish is the plausibility of the richness of approaches, and the fact that the old binary, state-versus-market description of the universe of productive resource-governance options profoundly understates the range of available institutional options open to large, complex market economies. There is

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[159] See Benkler, 26 Harv J L & Tech at 97–98, 101–24 (cited in note 32).

[160] For an overview of von Hippel and colleagues' work on the measurement of user innovation, see Eric von Hippel, Jeroen P.J. de Jong, and Stephen Flowers, *Comparing Business and Household Sector Innovation in Consumer Products: Findings from a Representative Study in the UK* (working paper, Sept 27, 2010), online at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1683503 (visited Sept 15, 2013); Jeroen P.J. de Jong and Eric von Hippel, *Measuring User Innovation in Dutch High Tech SMEs: Frequency, Nature and Transfer to Producers*, *5–6 (MIT Sloan Research Paper No 4724–09, Feb 27, 2009), online at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1352496 (visited Sept 15, 2013).

a wide and diverse set of practices that avoid the dilemma of choosing between the two sometimes equally problematic options: state and market.

The effect of this diversity of choices might be more easily understood by considering a classic debate over property and commons in public goods: the debate between Kenneth Arrow and Harold Demsetz over patents. Arrow had famously defended government funding of science on the observation that, because of nonrivalry and the "shoulders of giants"[161] effect, using property to stimulate innovation leads to systematic underutilization of the innovations, loss of welfare, and follow-on innovation.[162] Demsetz countered that, while there were efficiency losses, the error rate of a government funding agency as to where to focus research and funding was sufficiently higher than the error rate of a market-driven patent system—that it was better to incur the welfare losses Arrow had identified in exchange for the higher quality signal that the institutional arrangement of patents would offer firms in directing their research.[163] What is missing from Demsetz's response is the recognition that (a) most large-scale innovation investment occurs in firms, and firms are still managerial planning agencies; private planning is still planning, and gets in the way of follow-on research that could use the innovation's outputs in new directions; and (b) government funding does not necessarily involve government governance of the direction of research. As to the first point, patents limit the freedom of action of various follow-on innovators; while some can transact, not all can—the cost may be too high, or the application too far afield from what the owner sees as beneficial. In all these, limitations on patents that result in a broader freedom to operate in an open commons will result in more diverse experimentation and innovation. Similarly, science funding developed not as a government command-and-control system, but as a hybrid system that combines public provisioning (for example, the NIH budget),[164] with some high-level policy making, with

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[161] Suzanne Scotchmer, *Standing on the Shoulders of Giants: Cumulative Research and the Patent Law*, 5 J Econ Persp 29, 29 (Winter 1991).

[162] See Arrow, *Economic Welfare* at 623–25 (cited in note 47).

[163] See Harold Demsetz, *Information and Efficiency: Another Viewpoint*, 12 J L & Econ 1, 10–13 (1969).

[164] National Institutes of Health, *Overall Appropriations* (Department of Health and Human Services 2013), online at http://officeofbudget.od.nih.gov/pdfs/FY13/Vol%201%20Tab%202%20-%20Overall%20Appropriations.pdf (visited Sept 15, 2013).

a complex system of peer review of the allocation of these funding flows.

A similar trend toward mixing and matching governance structures, provisioning mechanisms, and open-access commons is visible throughout the networked economy. About 40 percent of software companies reported, as of 2010, developing at least some free or open-source software.[165] This follows a decade since IBM first announced its major strategic decision to contribute to open-source software.[166] Google's Android is open source.[167] What are these companies doing? Even where the basic provisioning is funded by the firm, it is placed in a governance structure that allows anyone to take, modify, and redistribute the code. Both Berkeley Software Distribution (BSD)–type FOSS licensing and the copyleft provisions of the GNU General Public License (GPL) create an open-access commons as far as use, distribution, copying, and modification of the software. Some of the provisioning is firm funded; some is peer production that is not funded at all or is not directly funded by a firm.[168] All the desiderata of widespread participation, testing, and development are based on the open-access characteristic of the licensing. But extensive academic work has shown that peer communities do graft diverse governance structures on such open systems: Chris Kelty's work on the Linux kernel and Apache;[169] the detailed analyses of the Debian community by Gabriella Coleman[170] and by Siobhán O'Mahony and Fabrizio Ferraro;[171] and extensive work on Wikipedia

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[165] See Josh Lerner and Mark Schankerman, *The Comingled Code: Open Source and Economic Development* 67 (MIT 2010).

[166] See *IBM Pledges 500 U.S. Patents to Open Source in Support of Innovation and Open Standards*, IBM News Room (IBM Jan 11, 2005), online at http://www-03.ibm.com/press/us/en/pressrelease/7473.wss (visited Sept 15, 2013). For an analysis of IBM's open-source patent pledge, see Benkler, *Wealth of Networks* at 46–47 (cited in note 150).

[167] See http://source.android.com (visited Sept 15, 2013).

[168] See Andrea Bonaccorsi and Cristina Rossi, *Comparing Motivations of Individual Programmers and Firms to Take Part in the Open Source Movement: From Community to Business*, 18 Knowledge Tech & Pol 40, 42–51 (Winter 2006) (reporting on the incentives that drive firms to engage in open-source projects and comparing them to the motivations of individual participants). See generally Sam Williams, *Free as in Freedom: Richard Stallman's Crusade for Free Software* (O'Reilly 2002).

[169] See Christopher M. Kelty, *Two Bits: The Cultural Significance of Free Software* 212 (Duke 2008).

[170] See generally E. Gabriella Coleman, *Three Ethical Moments in Debian* (working paper, Sept 15, 2005), online at http://ssrn.com/abstract=805287 (visited Sept 15, 2013).

[171] See Siobhán O'Mahony and Fabrizio Ferraro, *The Emergence of Governance in an Open Source Community*, 50 Acad Mgmt J 1079, 1088–92 (2007).

governance, most comprehensively by Joseph Reagle.[172] These studies describe governance structures grafted over these systems: usually meritocratic—mostly "do-ocracy" (government by those who show up and do the work); heavily consensus oriented (but requiring only rough consensus rather than creating a veto-rich environment of absolute consensus, and only among those who do the work and show up); a substantial degree of irreverence; redundant pathways so as to avoid conclusive decision making; rare use of formal processes; never of law or managerial fiat. We see similar structures for the governance of the basic Internet infrastructure itself.

The Internet Engineering Task Force (IETF) and the World Wide Web Consortium (W3C) are very different institutions that govern the core standards on which the Internet and World Wide Web, respectively, run. The IETF is still entirely anarchic—anyone can join by showing up, and the decision-making process is rough consensus, debate, and largely through consent and acquiescence.[173] The W3C has a more complex membership structure, with the strong charismatic leadership of Tim Berners Lee, but working groups that, as in the IETF, are open to all and which are fundamentally meritocratic.[174] Both TCP/IP and HTML (the core standards), however, are open commons—they are designed technically, and managed institutionally and organizationally, to be usable by anyone and to empower no one to exclude anyone from using them. They are open commons at the very heart of our communications system.

The details of each of these in particular matter less than the overall point. Open commons where "anything goes" may or may not be "tragic," depending on the characteristics of the resource set to which they apply. The public domain in information, knowledge, and culture that is "old" (by whatever definition one chooses) is purely open access, with no rules except of the accession of particular bits into the public domain. Many open commons do incorporate some form of governance to deal with provisioning, either initial or renewal, or congestion. There

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172 See Joseph Michael Reagle Jr, *Good Faith Collaboration: The Culture of Wikipedia* 117 (MIT 2010).

173 See Internet Engineering Task Force, *Getting Started in the IETF* (Internet Society), online at http://www.ietf.org/newcomers.html (visited Sept 15, 2013) (describing the structure and procedures of the IETF as "completely open to newcomers . . . no formal membership, no membership fee, and nothing to sign").

174 *Participation FAQ* (World Wide Web Consortium), online at http://www.w3.org/participate/faq.html (visited Sept 15, 2013).

is no single answer for how best to provision or renew a resource, or how to manage congestion, without losing the freedom to operate created by the commons. It is here that the context- and detail-intensive approach that Ostrom championed,[175] and that Frischmann together with Michael Madison and Katherine Strandburg have advocated with regard to knowledge and cultural commons,[176] allows us to synthesize the two schools. Detailed studies of peer production practices, open commons online, and various other human practices that treat their inputs and outputs as open commons but nonetheless require and instantiate governance structures are a critical part of our capacity to accept the sustainability and significance of commons, as well as how we go about designing new commons as new resources, or new failures of the property, firm, or state models come to light.

That the two schools of commons studies can be synthesized and made to complement each other does not, however, collapse them into each other. The Ostrom school is concerned with collective action with regard to resources where there are potential social dilemmas involved in the utilization of these resources.[177] The open-commons school emphasizes the comparative institutional advantages of commons over property where the benefits of the marginal increase in freedom to operate offered by commons relative to property is greater than the cost in terms of (a) reduced ability to appropriate through exclusion and (b) congestion, if any. The Ostrom school offers an admonition to make that cost-benefit analysis in terms that are resource- and context-specific, and offers a framework to evaluate the institutional structures aimed at governing these open commons, in particular when the error associated with government- or firm-based governance is greater than the error involved in social organization and self-governance. Both are necessary if we are to develop a more comprehensive and realistic model of the institutional diversity necessary to allow complex modern economies and societies to learn, adapt, and develop in an increasingly complex and uncertain world, relying as they all must on irreducibly fallible systems.

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[175] See Ostrom, *Governing the Commons* at 192–216 (cited in note 13) (offering a framework for analysis of commons).

[176] Madison, Frischmann, and Strandburg, 95 Cornell L Rev at 708 (cited in note 14).

[177] See Hess and Ostrom, *Introduction: An Overview of the Knowledge Commons* at 5 (cited in note 3).