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The Illusion of the Commons

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The Illusion of the Commons

Jonathan M. Barnett

Abstract

Intellectual property rests on a simple incentive rationale: without imitation barriers, innovators rationally decline to invest. But this blanket proposition is incompatible with markets where innovation proceeds without substantial recourse to intellectual property and imitation is widespread. This discrepancy sometimes drives the alternative view that intellectual property or other access barriers often or even usually are not prerequisites for intellectual production. But utopian understandings oversimplify the complex incentive structures and circumscribed conditions under which some markets can induce innovation without intellectual property or practical equivalents. A simple rational choice framework anticipates that sharing regimes - that is, innovation environments bereft of exclusionary barriers but governed by reputational norms - can sustain a viable habitat for innovation but inherently deteriorate as endowment heterogeneity, group size, asset values and capital intensities increase. Empirics substantially track theory: industries that sustain innovation without robust intellectual-property protections tend to be confined to low-stakes settings or make indirect recourse to other exclusionary instruments. Critically, however, it is also the case that voluntarily-formed sharing arrangements pervade even economically-intensive markets. Properly understood, these sharing arrangements do not substitute for property but provide a vital complementary mechanism that alleviates the transaction-cost burden of an exclusionary regime. Examination of three best cases for the view that intellectual production can proceed without intellectual property - premodern craft guilds, academic research and open source software - supports this intermediate position: sharing practices proliferate to facilitate the low-cost circulation of knowledge assets but are consistently embedded within a legal or technological infrastructure that implements some barrier to imitation.

September 2010

The Illusion of the Commons

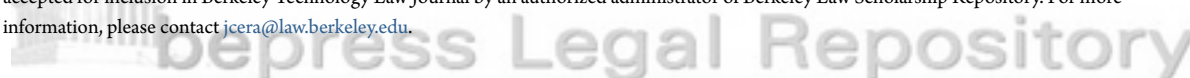
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THE ILLUSION OF THE COMMONS

Jonathan M. Barnett†

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I. INTRODUCTION

Conventional wisdom states that intellectual property or some other barrier to imitation is a prerequisite for intellectual production: without it, innovators¹ will decline to place capital at stake. But this proposition appears to be incompatible with markets where innovation proceeds with weak or no intellectual property rights and imitation is widespread.² For example, copyrights over music are routinely violated, yet music production does not appreciably slow; software is widely pirated or voluntarily released with minimal or even no protections against copying, yet product releases continue apace; property rights over scientific theories and findings are nonexistent, yet research proceeds forward. These observations form the basis for an intellectual family of related positions that I loosely group under the rubric of the “commons thesis.” Based on the observation that innovation apparently thrives in certain contemporary or historical environments without constraints on imitation, scholarly and popular commentators increasingly conclude that intellectual property can be substantially retracted or abolished in some, most, almost all, or even all other settings at a net social gain.² Casually formulated, typical expressions in this vein run along the following lines: “Pythagoras, Galileo, and Shakespeare didn’t have intellectual property but were really creative, so . . .” or “magicians, tattoo artists, and hair stylists don’t use intellectual property but are really innovative, so . . .” or “scientists and artists aren’t in it for the money, so . . .” Novel technologies have lowered the costs of copying, modifying, and distributing informational goods, and intellectual property or other exclusionary barriers can appear to be outdated roadblocks to the production and exchange of intellectual goods. The various slogans that advance the commons model (such as “information wants to be free,” “free culture,” “free software,” and “free science”) are inherently attractive, pervade contemporary discourse, and have made substantial inroads in legal and even economic scholarship on intellectual property. Indeed, it is difficult to defend any other position: what publicly-interested argument would remain to support access restrictions if we “know” these are unnecessary to

1. By “innovator,” I refer to individuals, firms or other entities that are engaged in the invention, creation and/or commercialization of intangible goods. “Innovation markets” encompasses markets or market segments principally or substantially consisting of intangible goods in the form of creative or technological products or processes.

2. See *infra* notes 8–10 and accompanying text.

support creation and invention? The commons thesis has arguably become the new conventional wisdom.

But complex facts deserve complex explanations. Both the old and the new orthodoxy fall far short of adequately capturing the nuanced strategies used by individuals, firms, and other entities to capture returns on innovation. In previous publications, I have emphasized that a monolithic property-rights view that identifies intellectual property as a strict precondition for intellectual production is incompatible with the widespread use of alternative instruments that supplement or sometimes even substitute for intellectual property.³ But it would be equally myopic to adopt the polar view (as the commons thesis in its various incarnations argues with various degrees of force) that intellectual production can typically proceed at vigorous levels without any meaningful legal or other barriers to unauthorized use. If that were the case, then much, if not all, of the existing intellectual property infrastructure would be a policy error of substantial proportions, and an exceptionally successful and persistent case of privately interested rent-seeking. (A priori that possibility, of course, cannot be excluded and often may appear to be quite plausible!)

This Article provides a set of theoretical and empirical arguments that together cast serious doubt on that possibility. The conditions under which environments bereft of property rights or other exclusionary instruments have supported, are likely to support, and actually do support, capital-intensive forms of innovation appear to be profoundly limited. As innovation environments “scale up” along certain key dimensions, a basic economic logic governs: access must be—and is—regulated at some point in order to deliver the revenue streams that support the costly activities required to generate and commercialize technological and creative innovation.

Hence what I call “the illusion of the commons.” Environments that apparently sustain substantial levels of innovation investment in the absence of intellectual property are typically supported by some combination of legal and/or extra-legal instruments that restrain access to some portion of the total “consumption bundle” of products and services. Across a broad set of otherwise disparate markets and periods, there is surprisingly little support for the widely-expressed view that the “commons”—by which I mean open-access or substantially open-access environments—provides a reliable model

3. See Jonathan M. Barnett, *Property as Process: How Innovation Markets Select Innovation Regimes*, 119 YALE L.J. 384 (2009) [hereinafter Barnett, *Property as Process*]; Jonathan M. Barnett, *Is Intellectual Property Trivial?*, 157 U. PA. L. REV. 1691 (2009) [hereinafter Barnett, *Trivial*]; Jonathan M. Barnett, *Private Protection of Patentable Goods*, 25 CARDOZO L. REV. 1251 (2004) [hereinafter Barnett, *Private Protection*].

for understanding the incentive structures that elicit economically intensive levels of innovation. That in turn casts doubt on the widely-expressed normative assertion that intellectual property rights are an artificial distortion in cultural and technological markets that otherwise thrive and have thrived without access limitations.⁴ Virtually the contrary is the case: economically significant levels of innovation investment almost never appear without some form of property rights or other access limitations that operate with an approximately equivalent effect. While this critical observation challenges the commons model as a reliable basis for positive analysis of innovation environments or normative design of innovation systems, it does not simply restore the old orthodoxy that unqualified property rights are a categorical precondition for innovation. That too would be a gross oversimplification. Analytical rigor demands an intermediate approach that can account for the complexity and diversity of funding and appropriation models across the rich variety of historical and contemporary innovation settings. That approach must account for the nuanced manner in which innovator populations both implement property rights and/or other access limitations in order to capture returns on investment, while maintaining cooperative relationships that reduce the transaction-cost burdens inherent to property rights and other access limitations.

This project starts by taking the commons model extremely seriously. To do so, I use a simple rational-choice framework to identify the circumstances under which the commons model could provide a feasible environment for intellectual production. The result is a hypothetical “sharing regime”⁵ that relies on social norms to support innovation in the absence of legal or other barriers to imitation. In this construct, reputation-driven norms support an approximately reciprocal exchange of knowledge assets over time and avoid the under-provision outcome that normally results in public goods settings without exclusionary instruments. Relative to a law-based regime that relies on formal property rights to sustain contribution incentives, this norm-based regime has a great advantage: it avoids the transaction costs that burden the creation, exchange, and transmission of intellectual assets under a formal property-rights regime. But the social savings from reduced transaction costs must be paid for with the social losses from limited regulatory power. Reputation-driven norms exert no force against one-shot or other participants that have no rational interest in accumulating reputational capital and, consistent with the core findings of the economic literature on the

4. *See infra* notes 8–10 and accompanying text.

5. My specific understanding of this term, as distinguished from some related terms in the literature, is described subsequently. *See infra* note 18.

private provision of public goods, can be expected to exhibit declining force in general as any market exhibits increased group size, economic values, capital-intensity requirements and variation in innovative capacity.⁶ In short, the sharing model works in settings that are small in size, scale, value, and diversity. As markets mature and grow along those same dimensions, however, the sharing model tends to become an obsolete technology for supporting innovation.

Contrary to burgeoning “IP-skeptical” and “IP-rejectionist” currents in recent commentary,⁷ a rational-choice framework anticipates as a theoretical matter few markets that would be able to sustain economically intensive levels of innovative output without property rights or other exclusionary instruments. Note that this is a positive, not a normative, proposition. It simply is the case that certain specified factors will drive innovators to migrate toward more securely shielded environments in order to recoup innovation investments. To assess the empirical strength of these expectations, I broadly review existing evidence concerning legal and extra-legal appropriation instruments that operate in markets where innovation proceeds subject to weak or substantially incomplete intellectual property rights. This survey exercise—which provides a novel taxonomy of sharing practices in intellectual goods markets—demonstrates virtually the converse to the commons thesis. Each market that sustains economically significant levels of innovation without active adoption and enforcement of intellectual property is always allied to some other legal or extra-legal instrument that limits unauthorized usage. Put differently: the commons to which the commons thesis aspires hardly ever seems to exist! Even sharing regimes that apparently make little or no use of exclusionary instruments to secure innovation returns support this thesis. Lacking obstacles to imitation, these markets tend to be confined to technologically primitive markets where innovators have relatively insubstantial investments at risk. Consistent with theoretical expectations, reputation-driven norms substitute for intellectual property in order to sustain innovation incentives in “little-IP” settings characterized by low numbers (or large numbers organized into collective groups), low endowment heterogeneity, low capital-intensity levels, and low asset values. But these reputation-driven incentive structures tend to be replaced by property-based arrangements in “big-IP” settings characterized by large numbers, high endowment heterogeneity, high capital-intensity levels, and high asset values. In short: whenever intellectual production scales up, it adopts some form of intellectual property or other access limitations.

6. Each of these terms is defined in greater detail *infra* Part II.

7. See *infra* notes 8–10 and accompanying text.

Both theory and empirics recommend that we virtually flip the commons thesis on its head. In economically intensive settings, intellectual production does require intellectual property or some other exclusionary instrument to secure returns and thereby induce innovation. Strikingly, this proposition is made most evident in case studies of three markets that should be—and are often referenced as—among the best cases for the view that intellectual production does not require intellectual property: pre-modern craft production, academic research, and open-source software. Closer analysis shows that these “best cases” provide some of the most compelling illustrations against the commons thesis. Contrary to the “free appropriation” environment envisioned by the commons model, these markets rely on a complex mix of legal, extralegal and/or technological barriers, as complemented by reputational norms, to generate revenue streams in a manner that is ultimately consistent with the standard incentive framework. Critically, unmasking the illusion of the commons does not simply reiterate, but substantially re-orient, the standard incentive-based view of intellectual property. If we discard value-driven aspirations that innovation can typically proceed without any robust imitation barriers (or that innovation can typically proceed only with the most robust imitation barriers), then we can usefully reallocate scholarly resources to an alternative and strictly positive line of inquiry. Namely, the manner in which innovation markets use a mix of both property-based and sharing-based arrangements to support innovation incentives while mitigating the transaction costs and other social losses imposed by property rights and other exclusionary instruments. This approach offers a useful tool by which to capture the mixed incentive structures of real-world markets. It therefore improves upon both the new conventional wisdom, which privileges and consequently over-predicts the use of sharing arrangements, and the old conventional wisdom, which privileges and consequently over-predicts the use of property-based arrangements.

This Article’s core proposition is as follows: sharing arrangements are ubiquitous in innovation markets but, at least in economically significant settings, consistently operate against the background of property rights or some other combination of exclusionary instruments. The case studies vividly illustrate this nuanced view. Separated by great differences in time, location, and industry, each market operates subject to a mixed-form innovation regime that embeds sharing arrangements within a surrounding property infrastructure. This structure consists of: (1) a “sharing core,” where similarly-endowed innovators exchange knowledge assets subject to certain norm-based constraints, which is then shielded by (2) a “property perimeter” constituted by legal or extra-legal access restrictions, which in turn support a

bundled set of excludable products and services that generate revenue streams consistent with a conventional property regime. Under this hybrid regime, sharing practices do not substitute for intellectual property, but instead supply a transactional lubricant that facilitates the creation and improvement of intellectual goods while leaving intact an underlying infrastructure constituted by property rights and/or other exclusionary instruments. Again, this is a positive and not a normative proposition. It simply is the case that certain specified factors will drive firms or individuals to adopt sharing arrangements in order to eliminate the transaction-cost burdens inherent to a property regime and realize other gains from pooling knowledge assets. For this purpose, *property is a tonic, not an antidote*: sharing arrangements can scale up to “high stakes” environments by using property, contract, technology, and other exclusionary instruments to regulate access, thereby precluding the unraveling threats that threaten stand-alone sharing regimes.

Part II reviews claims to the effect that intellectual property or other exclusionary protections are not a prerequisite for intellectual production. Part III presents a stylized construct of a sharing regime that sustains innovation by recourse to social norms in lieu of property rights. Part IV presents a survey of empirical evidence on sharing regimes in cultural and technology markets. Part V presents case studies of pre-modern craft production, academic research, and open-source software.

II. COMMON THOUGHTS ON THE COMMONS

A substantial body of scholarly, popular, and policy discourse, as well as partisan positions taken by user communities and advocacy organizations, contest with varying degrees of intensity the conventional assumption that property rights or other imitation barriers are a typical precondition for innovation.⁸ Typical formulations anticipate a “world-to-come,” where

8. Any list of references will inherently be selective. *See, e.g.*, LAWRENCE LESSIG, *FREE CULTURE: HOW BIG MEDIA USES TECHNOLOGY AND THE LAW TO LOCK DOWN CULTURE AND CONTROL CREATIVITY* (2004) [hereinafter LESSIG, *FREE CULTURE*], at 29 (giving examples of non-consented use of original material by scientists, Hollywood studios, and Shakespeare), 53–61 (giving examples of film, TV, radio, and cable TV industries that were originally founded through various forms of intellectual piracy), 305–06 (arguing that an intellectual property regime that requires obtaining consent to use proprietary content stifles novel opportunities for creative expression facilitated by digital and online technologies); LAWRENCE LESSIG, *THE FUTURE OF IDEAS: THE FATE OF THE COMMONS IN A CONNECTED WORLD* 12–14 (2001) [hereinafter LESSIG, *FUTURE OF IDEAS*] (providing examples of musical creation, scientific research, and software development where innovators build on previous contributions without consent as characteristic of intellectual production); Michael A. Carrier, *Cabining Intellectual Property Through a Property Paradigm*, 54

informational goods are disseminated costlessly by intrinsically and/or altruistically motivated individuals assembled into spontaneously-ordered communities. Other formulations recall a “world-that-once-was,” where property rights were mostly absent and intrinsically and/or altruistically-motivated individuals exchanged knowledge in a collegial pursuit of intellectual inquiry and creative expression. For the commons literature, an open-access environment constitutes the natural policy baseline: that is, intellectual production often or typically proceeds well without intellectual property, which therefore largely reduces to a rent-seeking enterprise at the expense of the larger public.⁹

That of course begs the operational question: how do property-free environments induce innovators to spend resources on generating freely appropriable inventions? Or, as any investor would ask an entrepreneur: what is your revenue model? The commons literature often tends to bypass this question as immaterial: that is, it takes the view that innovators are motivated substantially or primarily by intrinsic motivations (e.g., “love of creation”) or altruistic motivations (e.g., “dedication to science”), in which case no remunerative mechanism need be identified.¹⁰ Relaxation or removal of the

DUKE L.J. 1, 36–37 (2004) (questioning the need for copyright, given that “many forms of creative expression—such as fashion, new words and slogans, jokes, and magic tricks, and the food industry—have flourished in the absence of protection”); Madhavi Sunder, *IP*³, 59 STAN. L. REV. 257, 260–61 (2006) (arguing that “rapid-fire technological advances and new forms of creative output . . . undermine utilitarian intellectual property law’s very premise: that intellectual property rights are necessary to incentivize creation”). For an example from the advocacy literature, see NANCY KRANICH, INFORMATION COMMONS: A PUBLIC POLICY REPORT 10 (2004) (noting that “throughout history” commons regimes have characterized pre-modern literary and agricultural production, with the suggestion that therefore creative production can proceed vigorously without intellectual property rights; however, author notes subsequently that “commons” research identifies restrictive conditions under which commons regimes are a sustainable regime for intellectual production). For an example from the popular literature, see John P. Barlow, *The Economy of Ideas*, WIRED, March 1994, at 8–9 (noting that storytelling, jazz improvisation, stand-up comedy routines, and other cultural forms proceed by incremental practices of free circulation and improvement, for which copyright law makes no accommodation, and arguing generally that intellectual property is of doubtful value given that innovators can usually accrue substantial returns as a result of first-mover advantage).

9. See, e.g., LESSIG, *FUTURE OF IDEAS*, *supra* note 8, at 12 (“[F]ree resources have always been central to innovation . . .”).

10. See, e.g., James Boyle, *The Second Enclosure Movement and the Construction of the Public Domain*, 66 LAW & CONTEMP. PROBS. 33, 45–46 (2003) (referring to the “innate human love of creation that continually drives us to create new things even when *homo economicus* would be at home in bed, mumbling about public goods problems”). The role of non-instrumental motivations forms the basis for a “social” model of intellectual production presented in YOCHAI BENKLER, *THE WEALTH OF NETWORKS: HOW SOCIAL PRODUCTION TRANSFORMS MARKETS AND FREEDOM* Chs. 3–4 (2006), which elaborates on arguments in Yochai

“rationality constraint”—that is, expected revenues must equal or exceed expected costs—may be plausibly compatible with certain “low stakes” fields of creative endeavor. It is not plausibly compatible, however, with the high stakes that private entities invest in developing and commercializing new technologies and ideas: for example, more than \$800 million on average in the case of a pharmaceutical drug¹¹ or more than \$3 billion in plant construction costs in the case of a semiconductor chip.¹² Attenuation or outright rejection of an instrumentalist model of innovative behavior distinguishes commons-styled claims from economic arguments that identify limited circumstances where imitation promotes innovation by profit-seeking firms. Invariably these arguments specify a remunerative mechanism that directly or indirectly rewards innovators based on some exclusionary protection. These models contemplate some form of property rights or other exclusionary instruments, which apply to some users or product attributes,¹³ re-appear at some other point in the aggregate bundle of products and services,¹⁴ or are waived by entitlement holders until some later time.¹⁵

Benkler, *Sharing Nicely: On Shareable Goods and the Emergence of Sharing as a Modality of Economic Production*, 114 YALE L.J. 273 (2005) [hereinafter Benkler, *Sharing Nicely*]; and Yochai Benkler, *Coase's Penguin, or, Linux and The Nature of the Firm*, 112 YALE L.J. 369 (2002) [hereinafter Benkler, *Coase's Penguin*].

11. See Joseph A. DiMasi et al., *The price of innovation: new estimates of drug development costs*, 22 J. HEALTH ECON. 151, 166 (2003) (estimating average capitalized costs of \$802 million for molecule identification and testing for drugs that underwent the FDA approval process in the 1990s (as calculated on a fully capitalized basis in 2000 dollars)). This figure is an underestimate insofar as it does not include production, distribution or marketing costs.

12. See Iikka Tuomi, *The Future of Semiconductor Intellectual Property Architectural Blocks in Europe*, JRC SCIENTIFIC AND TECHNICAL REPORTS 74 (2009).

13. See, e.g., Stan J. Liebowitz, *Copying and Indirect Appropriability: Photocopying of Journals*, 93 J. POL. ECON. 945 (1985) (arguing that original producers can price-discriminate so as to appropriate the value attributed by initial consumers to the ability to make subsequent copies); Lisa N. Takeyama, *The Intertemporal Consequences of Unauthorized Reproduction of Intellectual Property*, 40 J.L. & ECON. 511, 512–13 (1997) (arguing that imitators who saturate the low-end market allow high-end producers to credibly commit to higher-valuation “first-period” consumers that they will not subsequently sell to lower-valuation consumers at a lower price, thereby resolving the time-contingency obstacle to supracompetitive pricing).

14. See, e.g., Jonathan M. Barnett, *The Host's Dilemma: Strategic Forfeiture in Platform Markets for Informational Goods*, HARV. L. REV. (forthcoming 2011) [hereinafter Barnett, *Host's Dilemma*] (showing that platform holders in technology markets give away access or otherwise forfeit control in order to induce user investments that enhance the value of the platform, which in turn promotes the sale of complementary private goods).

15. See, e.g., Lisa N. Takeyama, *The Welfare Implications of Unauthorized Reproduction of Intellectual Property in the Presence of Demand Network Externalities*, 62 J. IND. ECON. 155, 165 (1994) (implying that network externalities motivate producers to give away samples in order to build an initial platform that increases demand for the product in the long-term). For similar arguments with respect to software publishers in particular, see Kathleen Reavis Conner & Richard P. Rumelt, *Software Piracy: An Analysis of Protection Strategies*, 37 MGMT. SCI.

Surprisingly, this recourse to property is not inconsistent with some of the most ardent expressions of the commons thesis. These lines of argument often refer to some reduced level of property-rights protection in order “to achieve balance,” but then fail to integrate this concession with the commons-styled claims that form the bulk of the remaining argument.¹⁶ Much of this Article is devoted to making explicit what is almost always implicit—or explicit but dismissively acknowledged—even in some of the strongest critiques of intellectual property. Namely, this Article identifies and describes the staying power of property rights or other exclusionary instruments in innovation markets that demand economically significant levels of investment. Property—understood broadly to refer to legal and any other form of exclusionary protection—is ubiquitous in markets for intangible goods. Recognizing and addressing directly this fact allows for construction of an integrated framework that accounts for both the staying power of “property” in markets characterized by widespread imitation and the staying power of “sharing” in markets characterized by robust innovation. Surprisingly, the same argument that establishes the inherent weakness of stand-alone sharing environments anticipates that sharing practices will persist and thrive within the secure perimeter established by property rights or other exclusionary instruments.

III. THEORY: THE FRAGILITY OF THE COMMONS

In this Part, I use a rational-choice framework to anticipate the conditions under which innovation incentives could be sustained in an environment largely bereft of intellectual property or other exclusionary

125, 126 (1991), and Ariel Katz, *A Network Effects Perspective on Software Piracy*, 55 U. TORONTO L.J. 155, 156–57 (2005).

16. For example, Professor Lessig, a leading skeptic of copyright, is careful to state that he seeks a “balance between free and controlled resources” in intellectual property law. See LESSIG, *FUTURE OF IDEAS*, *supra* note 8, at 72. Other commentators have observed, however, that this statement often jars with the relatively unqualified tenor of his critique against copyright in general. See, e.g., Sonia Katyal, *Ending the Revolution*, 80 TEX. L. REV. 1465, 1471–72 (2002) (reviewing Lessig’s *Future of Ideas*, noting that Lessig states that he maintains strong belief in private ownership but observing that this qualification is “slightly disingenuous” insofar as it is not reconciled with the general argument that copyright is unnecessary to support creativity); Julia D. Mahoney, *Lawrence Lessig’s Dystopian Vision*, 90 VA. L. REV. 2305, 2324 (2004) (reviewing Lessig’s *Free Culture*, noting that Lessig states that he is committed to “balance” in intellectual property but observing that he takes the view that peer-to-peer cooperative technologies should flatly trump intellectual property protections). In a recent book, Professor Lessig appears to adopt a more nuanced position, arguing that “sharing economies” and “commercial economies” can coexist in cultural markets. See LAWRENCE LESSIG, *REMIX: MAKING ART AND COMMERCE THRIVE IN THE HYBRID ECONOMY* 177–78 (2009).

barriers. Consistent with an economic approach, this framework assumes that participants in the innovation and commercialization process have rationally self-interested motivations: that is, effort will not be forthcoming unless it results in positive expected net benefits.¹⁷ To reconcile rational innovation with the absence of property rights or other access barriers, I design a hypothetical “sharing regime”¹⁸ that sustains innovation incentives through social norms that encourage original contributions and discourage excessive imitation. This norm-based mechanism is neither unique nor comprehensive; that is, it is neither the only model that could be formulated to sustain innovation without exclusionary barriers consistent with rational choice constraints, nor a model that encompasses all relevant variables.¹⁹ However, it may be viewed as a barebones heuristic to anticipate at a general level the conditions under which innovation can be feasibly maintained without barriers against imitation. Following the economics and political-

17. To be clear, I do not deny that altruistic or intrinsic motivations play some role in driving innovation, although this is immaterial where the firm, rather than an individual, is the operative decision maker. This is the almost universal case in technology markets and in cultural markets that require large capital investments to fund innovation or, more importantly, distribution. Moreover, by removing this factor from the analysis, we can assess how much “work” non-instrumentalist motivations would have to do to sustain innovative output. A more complex model of innovator behavior would incorporate both instrumentalist and non-instrumentalist motivations in the limited settings where that is likely to make a practical difference.

18. Alternative terms used in the literature are “semicommons,” a term recently gaining currency in the intellectual property literature, or “limited-access commons,” a more established term with a well-known valence in the political-science and economics literature on common-pool resource governance. Both terms denote fields of activity where there is open access to the relevant asset subject to (1) in the case of a “limited-access commons,” constraints imposed by community norms or other informal understandings, and (2) in the case of a “semicommons,” constraints imposed by limited applications of property rights. A “sharing regime” as used in this Article encompasses both terms insofar as it denotes both (1) open environments that operate subject to constraints imposed by norms and (2) closed environments that operate subject to constraints imposed by contract and intellectual property. For applications of the semicommons concept in the intellectual property context, see Michael J. Madison et al., *Constructing Commons in the Cultural Environment*, 95 CORNELL L. REV. 657 (2010); Henry E. Smith, *Governing the Tele-Semicommons*, 21 YALE J. ON REG. 289 (2005); Robert A. Heverly, *The Information Semicommons*, 18 BERKELEY TECH. L.J. 1127 (2003); and, for the first use of the term, Henry E. Smith, *Semicommon Property Rights and Scattering in the Open Fields*, 29 J. LEGAL STUD. 131 (2000). For a helpful survey of the various usages of these terms, see Lee Anne Fennell, *Commons, Anticommons, Semicommons*, in RESEARCH HANDBOOK ON THE ECONOMICS OF PROPERTY LAW 25 (Kenneth Ayotte & Henry E. Smith eds., forthcoming 2011).

19. Note that an obvious non-exclusionary alternative regime is a grant-based or other cash subsidy system funded by taxpayer contributions, which suffers from the informational inefficiencies inherent to any non-price-based allocation system, but avoids the deadweight losses inherent to imitations on access to non-rival goods. For sake of brevity, this option is excluded from consideration.

science literature on informal governance of “common pool” resources (as pioneered by 2009 Nobel Prize Winner Elinor Ostrom)²⁰ and the law-and-economics literature on “law and norms” (as pioneered by Professor Robert Ellickson, among others),²¹ the proposed regime replaces formal law, which coercively deters imitation, with informal norms that induce an approximately equivalent outcome. This exercise identifies circumstances where social norms can plausibly achieve collectively beneficial outcomes roughly equivalent to those that are achieved through legal sanctions. However, as is sometimes overlooked in the literature that references or applies the common-pool and law-and-norms approaches, it is important to keep in mind the limited circumstances under which social norms may replicate the outcome that would certainly be achieved by robust property rights. A norm-governed innovation regime is a locally effective—but low-cost—apparatus under a narrowly defined set of conditions. That offers a feasible but substantially imperfect substitute for its legal equivalent, which is a universally effective—but high-cost—apparatus under a broadly defined set of conditions.²²

A. REGIME STRUCTURES

Historians of science and technology generally agree that innovation is usually a cumulative process initiated by an original innovator, who contributes the initial major innovation, and then continued by subsequent innovators,²³ who contribute incremental improvements to the original innovation.²⁴ Collectively, these contributions constitute what I call the “innovation pool,” which may be construed as a stock of technological and/or creative inputs from which innovators can draw subject to any legal,

20. See ELINOR OSTROM, GOVERNING THE COMMONS: THE EVOLUTION OF INSTITUTIONS FOR COLLECTIVE ACTION (1990).

21. See ROBERT C. ELICKSON, ORDER WITHOUT LAW: HOW NEIGHBORS SETTLE DISPUTES (1991).

22. For some readers, the review of basic game-theoretic concepts (in particular, *infra* Section III.B) will be familiar; however, potential redundancy is sacrificed in order to describe precisely the formidable conditions that a sharing regime must satisfy in order to provide any plausible substitute for legal or other barriers against imitation.

23. The distinction between “original” and “subsequent” innovators is equivalent to other distinctions in the literature between “pioneers” and “improvers” or “first movers” and “second movers.”

24. See JOEL MOKYR, THE LEVER OF RICHES: TECHNOLOGICAL CREATIVITY AND ECONOMIC PROGRESS 12–13 (1990) (arguing that innovation often proceeds by introduction of a “macroinnovation,” which is then refined and developed by a long series of “microinnovations”).

technological, or other access limitations.²⁵ An innovation regime that maximizes cumulative innovative output over time must navigate the inherent tradeoff between supporting the incentives of original and subsequent innovators. First, it must sustain original innovators' incentives to make contributions to the innovation pool, which demands restrictions on access that increase transaction costs and input costs for subsequent innovators. Second, it must sustain subsequent innovators' incentives to generate derivative applications by making withdrawals from the innovation pool, which demands relaxations of access that reduce transaction costs and input costs for subsequent innovators.

Three broadly defined regimes can be instituted to govern contributions to and withdrawals from the innovation pool. Each regime achieves a different tradeoff between original and subsequent innovation incentives. These options (summarized below in Table 1) are as follows: (1) an open-access regime (commons), which imposes no withdrawal limitations and no contribution requirements; (2) a closed-access regime (property),²⁶ which imposes complete withdrawal limitations through legal or technological constraints but does not impose any contribution requirements; and (3) a limited-access regime (sharing), which uses norm-based instruments to impose contribution requirements and substantially incomplete withdrawal limitations. At one extreme, a commons environment eliminates all access restrictions and the attendant cost burden on subsequent innovation, but does not protect any portion of the innovation pool. This eliminates all incentives for original innovation, so that it can be set aside as a feasible solution to the under-innovation problem. At the other extreme, a property regime contemplates no unprotected portions of the innovation pool. This supports first-mover innovation but does so by imposing the cost burdens

25. This concept is inspired by the empirical literature on informal governance of common pool resources, which describes informal governance structures for renewable resource pools that are otherwise subject to individually rational overuse leading to a collective loss in the form of resource depletion. For the leading source, see OSTROM, *supra* note 20. These governance structures seek to avoid resource depletion by regulating individual usage over time so as to ensure that the average "withdrawal rate" does not exceed the average "replenishment rate," but without setting overly strict limitations that fail to maximize the pool's economic yield. While the analogy to a renewable resource pool is imperfect given the inexhaustibility of intellectual assets, it is applicable to the extent that, absent any limitations on the surplus of withdrawals over contributions from the collective innovation pool, innovators will be unable to accrue reputational (and collateral financial) returns, thereby precipitating an under-innovation outcome.

26. Note that a more exact term for "property regime" would be "proprietary regime" as I mean to include any regime that relies on legal *or* extralegal barriers to restrain imitation. However, the "property/commons" dichotomy is well-established in the literature so I avoid multiplying terms.

that attend a formal property-rights system, which discourages subsequent innovation.²⁷ Between these two polar alternatives lies a rich variety of intermediate sharing regimes, each of which protects some but not all portions of the innovation pool, thereby enhancing original innovation incentives relative to an open-access regime but without fully incurring the transaction and other costs that can burden subsequent innovation under a closed-access regime.

Table 1: Regime Comparison

Regime	Regulatory Instrument	Contribution Requirements	Withdrawal Limitations
Commons	None	No	No
Sharing	Norms	Yes	Yes, but incomplete
Property	Law	No	Yes

To induce innovative output without recourse to the costly apparatus of property rights or other exclusionary protections, a sharing regime must implement two social norms: (1) a contribution norm, which mandates that innovators make a certain minimum level of original contributions to the innovation pool, which is then freely accessible, and (2) a withdrawal norm, which sets a maximum limit to withdrawals by subsequent innovators from the innovation pool (or, in its weaker form, an attribution norm that allows unconstrained withdrawals but requires that subsequent innovators give credit to original contributors.)²⁸ Assuming sufficient compliance among the innovator population (the conditions for which are elaborated in the next Section), these contribution and withdrawal norms together implement a modified reciprocity principle that sustains innovation even in the absence of legal or other exclusionary barriers. Each innovator rationally makes original contributions to the common pool with two expectations. First, given general compliance with the contribution norm, it will withdraw from the

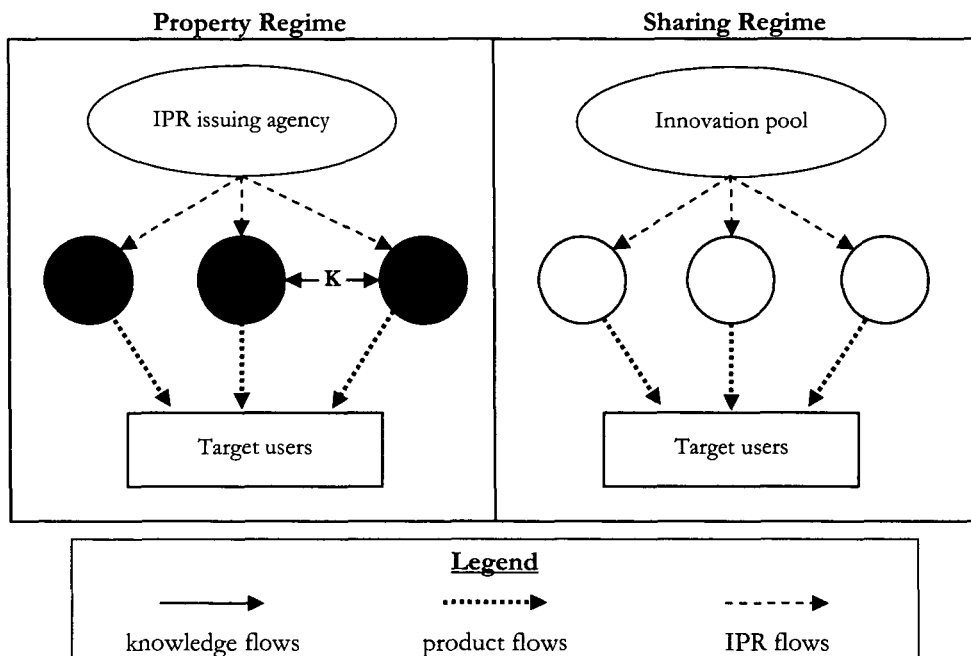
27. It may be argued that this result would not work because the first-mover innovator will rationally make its intellectual goods available to lower-cost *n*-mover innovators in order to generate derivative applications for mutual profit. This type of claim (which is equivalent to the “prospect” theory of patent rights proposed by Edmund W. Kitch, *The Nature and Function of the Patent System*, 20 J.L. & ECON. 265 (1977)) is subject to the objection that efficient contracting may be frustrated by strategic behavior, transaction costs in identifying and negotiating with follow-on innovators, and other inefficiencies associated with protected market positions. For further analysis of these difficulties, see Suzanne Scotchmer, *Standing on the Shoulders of Giants: Cumulative Research and the Patent Law*, 5 J. ECON. PERSP. 29 (1991) (discussing how to divide joint profit among innovators when one innovator’s technology builds on another’s).

28. This is the prevailing norm in academic research, *see infra* Section V.B.

pool over time roughly the same value as it contributes to it. Second, given general compliance with the withdrawal norm, there will exist some positive distance between original contributions and derivative applications, thereby precluding perfect substitution that would otherwise prevent the former from earning any premium over the latter²⁹ (in which case the standard under-innovation result would prevail). Together these two norms provide innovators with substantially unimpeded access to the innovation pool, thereby reducing total innovation costs, while imposing some limitations on withdrawals from the pool, thereby generating remunerative streams that sustain incentives to make further contributions to the pool.

Law-based property regimes and norm-based sharing regimes generate starkly different transaction structures for the generation, transmission and exchange of intellectual goods, as rendered graphically in Figure 1 below. Under a property regime, unauthorized uses of intellectual goods are punished at a high cost by legal sanctions enforced through formal dispute-resolution processes based on intellectual property rights issued by a state agency. This formal infrastructure generates a closed exchange pattern consisting of an atomized sequence of high transaction-cost negotiated transfers of intellectual goods (as denoted by *K* in Figure 1 below), each of which is held on an exclusive basis by an entitlement holder. Under a sharing regime, excessive withdrawals from the innovation pool and failure to make original contributions to the innovation pool are punished at low cost through business, reputational, and other social sanctions assessed by the market. This informal infrastructure generates an open exchange pattern consisting of a continuous flow of low transaction-cost non-negotiated transfers of intellectual goods, none of which is held on an exclusive basis (at least in its entirety) by any party.

29. That is: if the imitation is a perfect economic substitute for the original, then the original innovator will be unable to demand any price above marginal cost, which in turn will prevent recoupment of the fixed costs of research and development, all of which are borne by the original innovator.

Figure 1: Alternative Regimes (Pure Form)³⁰

Assuming the existence of an enforcement technology to elicit contributions to, and restrain withdrawals from, the innovation pool, a sharing regime would appear to constitute a collectively preferred arrangement that outperforms both commons and property regimes. First, the sharing regime outperforms a commons regime by securing substantial returns for first-mover innovators. Second, it outperforms a property regime by reducing the transaction costs and input costs borne by subsequent innovators. This abstract characterization translates into economic terms the strong attraction the commons model exerts over popular discourse and a good deal of scholarly commentary. High appropriation capacities combined with low transaction costs are obviously preferable to the high appropriation capacities combined with high transaction costs of a formal property regime. It now remains to identify the conditions under which this is a feasible alternative. As we shall see, those conditions are not easily satisfied.

30. As used in Figure 1 (and subsequent Figures), a blank circle refers to an “open” innovator that participates in a nominal-cost exchange of intellectual assets (i.e., a sharing arrangement); a darkened circle refers to a “closed” innovator who does not. “K” refers to any type of contractual arrangement. “IPR” refers to intellectual property right.

B. THE COOPERATION GAMBLE

From the skeptical perspective of a rational-choice observer, a sharing regime is an academic exercise in naive utopianism. In the absence of any credible detection and enforcement mechanism, no innovator has any incentive to incur the costs required to comply with the underlying reciprocity norms, in which case property rights are restored as the unique solution to under-innovation. This can be elaborated by applying the well-known logic of the “prisoner’s dilemma” game. Suppose a market occupied by two innovators, each of whom must release an innovation for a new product season. Each innovator can elect between two actions: *cooperate* (i.e., comply with sharing norms, resulting in innovation), which results in an original contribution being developed at great cost, or *defect* (i.e., not comply, resulting in imitation), which immediately replicates at little cost any original contribution made by the other innovator. The pathological result is predictable. While it may be collectively rational over the course of multiple seasons if both innovators elected *cooperate*, thereby resulting in a rich stock of technological and creative inputs to support further innovation, it is individually rational in any individual season for each innovator to elect *defect*, thereby capturing the gains from the innovation without incurring the associated development costs. If these innovators are unable to make a credible commitment to elect *cooperate*, then each innovator elects *defect*, resulting in a “waiting game” that yields zero innovation.

But it is well known that this dilemma is not without a possible solution. So long as innovators are repeat players with sufficiently low discount rates and interact over an indefinitely repeated sequence, each may rationally cooperate (i.e., innovate). Any innovator will cooperate if it expects that discounted future gains in the event of mutual cooperation exceed “one-shot” gains, less discounted future losses from a single defection (and so long as the anticipated losses from “incorrectly” electing cooperate in any single round are not too great).³¹ Hence, even without the coercive force of law, a repeat-player innovator will sometimes “gamble” by electing *cooperate*—without perfect assurance that the other innovator will do the same. But this

31. The game theory literature has developed multiple equilibrium strategies in the repeated prisoner’s dilemma game. See JEAN TIROLE, *THE THEORY OF INDUSTRIAL ORGANIZATION* 245–47, 258–59 (1988). Perhaps the most well-known strategy is “Tit for Tat,” which requires that a player elect *cooperate* in the initial round of an iterated sequence, and in each round thereafter, but then to revert to *defect* if the other player elects *defect*. This “cooperative” equilibrium has the technical shortcoming such that (unlike the mutual defection outcome in a one-shot prisoner’s dilemma) it cannot be identified as the unique equilibrium; however, it does describe a possible equilibrium under certain reasonable assumptions.

solution has an important limitation. While long-term cooperation gains can induce forfeiture of short-term defection gains in an indefinitely repeated sequence of two-player interactions, this does not easily follow in multi-player settings where no individual election to forego short-term defection gains can independently determine whether a cooperative equilibrium will result. The result: every innovator rationally elects *defect* (i.e., waits to imitate),³² thereby restoring the collectively undesirable outcome of zero innovation.

This problem too is not without a tenable solution. So long as there exists an external instrument that sufficiently adjusts upward and downward, respectively, the relative expected payoffs of cooperation (innovation) and defection (imitation), then the “cooperation gamble” is restored as a rational choice. The anticipated breakdown of cooperative behavior in large-number settings has been addressed extensively through supplemental material benefits—what the public goods literature calls “selective incentives.”³³ These include reputational rewards and penalties, which fill the incentive gap that would otherwise result in individually rational defection. This can be illustrated by two well-studied “good” and “bad” solutions to collective-action failure. First, in industrial cartels, cheating on collectively beneficial output constraints is chronic, compelling cartels to invest in monitoring and punishment mechanisms to achieve sufficient levels of compliance to maintain collusive pricing.³⁴ Second, in informal governance of common-pool resources, monitoring and punishment mechanisms are almost universally used to support norm-based restraints on excessive withdrawals

32. There is a technical exception to this statement: even under the assumptions stated above, cooperation may still be individually rational where an individual's marginal contribution independently determines the total amount of the collective good that is provided (the so-called “weakest-link” scenario). This may have practical importance in some contexts. For further discussion, see Elinor Ostrom, *How Types of Goods and Property Rights Jointly Affect Collective Action*, 15 J. THEORETICAL POLITICS 239, 247–48 (2003) [hereinafter Ostrom, *Types of Goods*]; RICHARD CORNES & TODD SANDLER, *THEORY OF EXTERNALITIES, PUBLIC GOODS AND CLUB GOODS* ch. 2 (1986) (applying concepts from public finance).

33. See MANCUR OLSON, JR., *THE LOGIC OF COLLECTIVE ACTION: PUBLIC GOODS AND THE THEORY OF GROUPS* 60–65 (1965). For more extensive and updated discussions of Olson's thesis and the vast theoretical and empirical literature that it has spawned, see CORNES & SANDLER, *supra* note 32; TODD SANDLER, *COLLECTIVE ACTION: THEORY AND APPLICATIONS* (1992).

34. See 1 Alexis Jacquemin & Margaret E. Slade, *Cartels, Collusion, and Horizontal Merger*, in *HANDBOOK OF INDUSTRIAL ORGANIZATION* ch. 7 (Richard Schmalensee & Robert D. Willig eds., 1989).

from the relevant resource pool.³⁵ The same mechanism can operate in the innovation context: a sharing regime can allocate reputational rewards and penalties in order to shift relative cooperation and defection payoffs and fill the incentive gap that would otherwise result in individually rational defection from the governing contribution and withdrawal norms. Reputational rewards for original contributions and reputational penalties for excessive withdrawals, plus any collateral monetary or other material rewards and penalties, eliminate the individually rational “temptation to defect” and drive a repeat-player innovator to conclude that electing *cooperate* will maximize long-term payoffs (even if there is some positive likelihood that some other players will elect *defect*). The result: the innovator rationally complies with norm-based constraints on imitative behavior, and norm-based requirements to make original contributions, even in the absence of any legal obligation to do so.³⁶

C. MAKING COOPERATION LAST

So far I have identified two minimal conditions for a viable sharing regime in any large-number setting: (1) innovators must be repeat players with sufficiently low discount rates, and (2) a reputation-based enforcement technology must exist that sufficiently rewards compliance with, and penalizes violations of, the governing reciprocity norms. Those conditions may not appear especially strenuous and, as will be seen in the subsequent empirical discussion, roughly characterize a number of cultural, research, and design markets that rely substantially on reputational norms in order to induce innovative effort. But it is important to distinguish between viability and stability. Even if the minimal viability conditions are met, a norm-based sharing regime may still be vulnerable to individually rational defections, which in turn can spawn generalized defection among the innovator population that ultimately undermines the cooperative outcome. This Section

35. In the common-pool setting, monitoring and punishment mechanisms are almost universally used to support norm-based restraints on excessive withdrawals from the relevant resource pool. *See* OSTROM, *supra* note 20.

36. For completeness, it is necessary to address another potential difficulty. Even if reputational instruments could sufficiently correct any first-order incentive problem, this enforcement technology falls prey to a second-order incentive problem insofar as it too requires individually irrational expenditures to monitor norm-compliance and allocate reputational sanctions and rewards. As a practical matter, this problem may be mitigated in markets where the reputational infrastructure is administered (1) at relatively little cost to any individual, (2) by the immediate victim of any norm-violation (e.g., failure to attribute) or third-party participants with an independent profit-based incentive to do so, and/or (3) by collective organizations that spread the costs of norm-enforcement over a wide pool of individual beneficiaries, each of whom must then incur no more than a small contribution cost.

identifies a set of “stability conditions” that can enhance or decrease the likelihood that individually rational participants will voluntarily adhere to the reciprocity principle without which a sharing regime necessarily fails. Broadly consistent with the core findings of economic research on the private provision of public goods, this exercise suggests that a sharing regime is most likely to persist in “intimate” environments that exhibit the following features: (1) group size is small, (2) required capital investment is low, (3) innovative output has low economic values, and, what will be argued is a factor of special importance, and (4) innovative endowments (that is, innovators’ capacities and talents) are roughly equivalent in value.³⁷ To the extent one or more of these conditions are not substantially satisfied, a sharing regime becomes unstable. Innovators are likely to take defection actions that precipitate either a commons regime, resulting in the standard under-innovation outcome, or a property regime, which preserves some innovation under a higher transaction-cost burden.

1. *Innovator Options and Types*

Formerly I had assumed that an innovator could elect only among two possible actions: (1) *cooperate*, in the form of making contributions to, and constraining withdrawals from, the pool; and (2) *defect*, in the form of ceasing contributions to, and making unconstrained withdrawals from, the pool. To facilitate a more complex analysis, I will now expand the innovator’s choice set so that it includes two defection options: (1) *defect(copy)* (equivalent to the *defect* option set forth above), and (2) *defect(property)*, which refers to lobbying for, adopting, and enforcing state-provided property entitlements or, more typically, enforcing formally available but dormant property entitlements that have generally been unused. That is, an innovator can incur some cost, L , in order to “activate” a property entitlement through some combination of the aforementioned actions.³⁸ That in turn bars unauthorized access to the relevant intellectual good, which permits innovation to proceed at some positive level but under the higher transaction-cost burden associated with the maintenance and enforcement of formal property rights. To give a concrete example: star scientists can (and do) defect out of the sharing norms

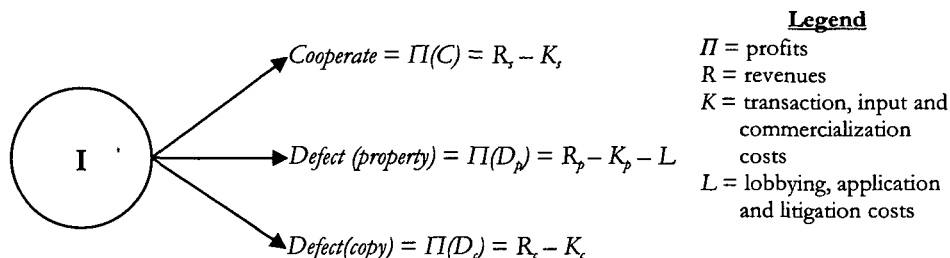
37. I emphasize the qualifier, “broadly consistent.” The vast theoretical and empirical literature on private provision of public goods is complex and not easily subject to generalization. However, the analysis below relies on the core findings of that literature with respect to each of the enumerated characteristics, noting any important open or disputed points where relevant.

38. More generally, *defect(property)* would include implementing technological measures that limit access. For simplicity of presentation, I focus on law-based access limitations in the form of property rights.

that have historically characterized academic research by accessing the state-provided patent system, which in turn can support financing and operating a for-profit business based on the legally protected technology.³⁹

The Figure below sets out the corresponding actions and payoffs facing any innovator (denoted below as “*I*”). Note that each defection action is individually rational for different reasons. *Defect(copy)* enables the innovator to avoid contribution costs and capture revenues from any party who elects *cooperate*. *Defect(property)* enables the innovator to block capture of its revenues by any party who elects *defect(copy)* (or, to a lesser extent, any party that elects *cooperate*). Using the notation below, we can state a simple condition for rational cooperation: it must be the case that $\Pi(D_p) < \Pi(C) > \Pi(D_c)$. If either of these inequalities is not satisfied, then the innovator will elect either *defect(copy)* ($\Pi(C) < \Pi(D_c)$) or *defect(property)* ($\Pi(D_p) > \Pi(C)$), respectively.⁴⁰

Figure 2: Innovator Actions and Payoffs



If we add one more feature to this setting, we can anticipate these defection actions based on innovator type. Suppose some distribution of “innovation endowments”—that is, the value of innovation talents and capacities—over a general innovator population. Now distinguish between two innovator types: (1) “strong” innovators who have an innovation endowment that is superior to the average endowment of the innovator population, and (2) “weak” innovators who have an innovation endowment that is inferior to the average endowment. An innovator’s endowment determines the costs it must incur in order to generate a given unit of

39. For a review of the empirical literature on this phenomenon and additional results, see Pierre Azoulay, Waverly Ding & Toby Stuart, *The Determinants of Faculty Patenting Behavior: Demographics or Opportunities?*, 63 J. ECON. BEHAV. & ORG. 559 (2007) (finding that patenting events are preceded by a flurry of publications).

40. An innovator may also elect *defect(withdraw)*, in the form of re-allocating investment resources to another use entirely, resulting in a payoff equal to $\Pi(w)$, where $\Pi(w) = R_w - K_w$. For ease of exposition, this option is generally not addressed above; for further additional discussion of this option, see *infra* note 44. Note that the various subscripts, “*c*,” “*p*,” and “*w*” refer, respectively, to the payoffs corresponding to an innovator’s election to *cooperate*, *defect(property)*, and *defect(copy)*.

innovative output. The stronger an innovator's endowment, the lower the costs it must incur to generate any given unit of innovative output. Conversely, the lower an innovator's endowment, the higher the costs it must incur to generate that same unit of innovative output. The relative strength or weakness of an innovator's endowment then implies its defection choice. For a weak innovator, any sufficient decrease in the reputational penalty for excessive withdrawals from the innovation pool (equivalent to an increase in the defection payoff) will induce it to elect *defect(copy)*: it incurs higher innovation costs relative to all other innovators and therefore can best compete as a copyist who avoids those costs almost entirely. That is, $\Pi(D_c) > \Pi(C)$ (and $\Pi(D_c) > \Pi(D_p)$). For a strong innovator, any sufficient decrease in the cooperation payoff (plus any reputational or other side payments) will induce it to elect *defect(property)*: it incurs lower innovation costs relative to all other innovators and therefore can best compete as an original innovator who can supply a higher quantity of innovative output at the lowest cost. That is, $\Pi(D_p) > \Pi(C)$ (and $\Pi(D_p) > \Pi(D_c)$).

2. Conditions for Cooperation

We must now identify the conditions under which a sharing regime is most likely to induce innovators to elect *cooperate* over the alternative options: *defect(copy)* or *defect(property)*. Precisely, what are the conditions under which an innovator will or will not expect that $\Pi(D_p) < \Pi(C) > \Pi(D_c)$? Existing research on the private provision of public goods, and the related literature on cooperative behavior in common-pool resource settings, identifies a number of factors that can influence individually rational incentives to comply with the norm-based constraints of a sharing regime.⁴¹ Some of the leading factors include: group size, capital intensity, economic value, and, of special interest in the ensuing discussion, endowment heterogeneity.⁴² Generally speaking, as explained in detail below, we can anticipate an inverse relationship between the value of each of these variables and innovators' propensity to elect cooperate over either of the two defection options. As

41. For a general overview of the factors that influence private provision of public goods, see CORNES & SANDLER, *supra* note 32. For an application of that literature to the common-pool resource context, see OSTROM, *supra* note 20.

42. The public goods literature and the common-pool governance literature, as well as the related literature on cartel stability, consider the effects of heterogeneity along several dimensions: resources, endowments, interests, preferences and costs, among others. I refer solely to heterogeneity in the value of innovators' talents and capacities. Note further that endowment heterogeneity is a function of the comparative value of participants' innovation assets or capacities; it is not a function of the identity of those assets or capacities. Hence, there will be a high level of endowment homogeneity where participants have different innovation assets or capacities that complement each other but have roughly equal values.

any given innovation environment exhibits increasing group size, capital intensity, economic values, and/or endowment heterogeneity, the defection payoff rises relative to the cooperation payoff. As one or more of those variables declines in value, the cooperation payoff rises relative to the defection payoff. In each case, we can then anticipate an innovator's defection choice based on its innovator type: weak innovators tend to elect *defect(copy)*; strong innovators tend to elect *defect(property)*.

The proposed relationships are summarized in Table 2 below and then explained in detail in the discussion that follows.

Table 2: Defection Actions as a Function of Innovator Type

Variable (Increasing)	Weak Innovator	Strong Innovator
Group Size	<i>Defect(copy)</i>	<i>Defect(property)</i>
Capital Investment	<i>Defect(copy)</i>	<i>Defect(property)</i>
Asset Value	<i>Defect(copy)</i>	<i>Defect(property)</i>
Endowment Heterogeneity	<i>Defect(copy)</i>	<i>Defect(property)</i>

a) Group Size

Any increase in the size of the innovator population erodes cooperation incentives for two reasons. First, it increases monitoring costs, thereby reducing the ability to punish defection with reputational sanctions and credit cooperation with reputational rewards, which effectively lowers the cooperation payoff. Second, it dilutes the individual share of collective benefits (assuming those are held fixed) that would be accrued under a sharing regime, which effectively lowers the cooperation payoff. A weak innovator will then elect *defect(copy)* in order to capture gains from stronger innovators, while a strong innovator will elect *defect(property)* in order to protect gains against weaker innovators. For both innovator types, the cooperation gamble becomes imprudent as the number of innovators sufficiently increases.

b) Capital Intensity

Suppose there is a capital-intensive innovation market that necessitates development and other "bringing to market" costs that are large relative to imitation costs borne by third parties. That means that both (1) the gains that would accrue to a party who elects *defect(copy)* and (2) the losses that would be incurred by an innovator who "incorrectly" elects *cooperate* are substantial. This both increases the payoff under *defect(copy)* and reduces the cooperation payoff. Without property rights or some other instrument by which to block imitation, large disparities between innovation costs incurred by firms that elect *cooperate* and imitation costs incurred by firms that elect *defect(copy)* imply that few if any firms will rationally make the former election. But this does

not mean that all firms will elect *defect(copy)*. While a weak innovator will elect *defect(copy)* in order to save on its disproportionately high innovation costs, a strong innovator will elect *defect(property)* in order to exploit its disproportionately low innovation costs and earn a net positive return. For both innovator types, the cooperation gamble becomes imprudent when the required capital investment is highest—or, most precisely, when the required innovation investment is substantially higher than the required imitation investment.

c) Asset Values

Strong innovators will have enhanced incentives to elect *defect(property)* where the market value of the relevant innovation in any given iteration is unusually high.⁴³ Compliance with sharing norms mandates forfeiture of a portion of that market value in any given iteration to other innovators in order to accrue long-term cooperation gains. While that long-term calculus may usually drive a repeat-player innovator to comply with the sharing norms, that may not be the case with respect to a “blockbuster” innovation for which an especially high one-time payoff could be earned if the innovator retained it exclusively by electing *defect(property)*. For the same reason, weak innovators have powerful incentives to elect *defect(copy)* when the economic value of the innovations generated by stronger innovators is especially high. For both innovator types, the cooperation gamble becomes imprudent when innovations are most valuable.

d) Endowment Heterogeneity

Relative differences in innovation endowments can predict the “direction” of an innovator’s defection in response to changes in group size, capital intensity, and economic values. But relative differences in innovation endowments can directly trigger individual defections from the sharing norms. Recall that a sharing regime (1) imposes a contribution requirement that mandates that each member contribute a certain minimum value to the innovation pool (which constitute “cooperation costs”) and (2) allows all members to withdraw up to a certain maximum value from the innovation pool (which constitute “cooperation gains”). If cooperation gains are not calibrated to reflect idiosyncratically higher or lower cooperation costs, then the cooperation gamble becomes imprudent for both strong and weak

43. Weak innovators may strategically elect *defect(property)* so as to obtain dubious property rights over valuable but unclaimed technologies and then extract nuisance settlements from stronger innovators. This corresponds to the “patent troll” phenomenon where non-operating patent holders allegedly sue technology companies opportunistically in order to extract cash settlements. For simplicity, I ignore this contingency.

innovators. A weak innovator incurs higher cooperation costs in light of its inferior innovation capacities: relative to all other innovators, it must expend greater resources to meet the contribution norm. As a result, a weak innovator is likely to anticipate that the payoff under *defect(copy)* exceeds the payoff under *cooperate*, resulting in imitation. A strong innovator incurs lower cooperation costs in light of its superior innovation capacities: relative to all other innovators, it must expend fewer resources to meet the contribution norm. However, that same fact implies that a strong innovator incurs higher indirect cooperation costs in light of the foregone profits that it could earn on the “open market” by exploiting its superior innovative capacities. Absent reputational side payments to reflect a strong innovator’s exceptional contributions, it is likely to anticipate that the payoff under *defect(property)* exceeds the cooperation payoff.⁴⁴ This positive relationship between endowment homogeneity and contribution incentives is consistent with evidence in a striking variety of contexts, including (1) cartels,⁴⁵ (2) common-pool resource settings,⁴⁶ (3) information sharing within organizations,⁴⁷ and (4) experimental simulations of public goods scenarios.⁴⁸

44. This assumes a full choice set. Even if the *defect(property)* option is not available (due to the absence of any legal or technological instrument by which to establish exclusivity), the strong innovator will elect *defect(withdraw)* in partial form. That is: it will constrain its innovative effort such that it meets the minimum contribution requirement but cease making further contributions to the innovation pool given the inability to earn returns that reflect its higher-value contribution. The result: a sharing regime preserves access at the cost of suppressing the highest-value forms of innovative output.

45. See Jacquemin & Slade, *supra* note 34, at 417–30 (reviewing studies showing that cost and product homogeneity promote cartel stability).

46. See generally Thrainn Eggertsson, *Open Access versus Common Property*, in PROPERTY RIGHTS: COOPERATION, CONFLICT AND LAW (Terry L. Anderson & Fred S. McChesney eds., 2002) (reviewing studies showing that endowment homogeneity tends to facilitate cooperative solutions to common-pool resource depletion); Jean-Philippe Platteau, *Solidarity Norms and Institutions in Village Societies: Static and Dynamic Considerations*, in THE HANDBOOK OF THE ECONOMICS OF GIVING, ALTRUISM AND RECIPROCITY (Serge-Christopher Kolm & Jean Mercier Ythier eds., 2006). For further discussion, see Ostrom, *Types of Goods*, *supra* note 32, at 257–58 (describing some limited diversity of results).

47. See generally Brian K. Thorn & Terry Connolly, *Discretionary Data Bases: A Theory and Some Experimental Findings*, 14 COMM. RES. 512 (1987) (finding that sharing of information among organization’s employees tends to decline as asymmetries in information values and benefits increase across participants).

48. These experiments tend to find that private contributions decrease as endowment homogeneity decreases, and increase as endowment homogeneity increases. See John O. Ledyard, *Public Goods: A Survey of Experimental Research*, in HANDBOOK ON EXPERIMENTAL ECONOMICS 111, 158–60 (John Kagel & Alvin Roth eds., 1995); see also Steven Hackett et al., *The Role of Communication in Resolving Commons Dilemmas: Experimental Evidence with Heterogeneous Appropriators*, 27 J. ENVTL. ECON. & MGMT. 99 (1994) (finding that in *n*-person commons dilemmas, endowment heterogeneity reduces earnings and is associated with a reduced ability to agree on allocation rules). The theoretical public-goods literature observes that the

3. *From Individual to Collective Defection*

So far I have described the conditions under which a sharing regime is most likely to induce individual innovators to elect *cooperate* over *defect(copy)* or *defect(property)* and, by implication, the conditions under which they are least likely to do so. But individual defections are only of interest to the extent that they translate into collective defections from the sharing norm among substantial portions of the innovator population. That unraveling effect follows logically from the prisoner's dilemma described at the beginning of this Part. Even an isolated defection by a single innovator may threaten the stability of a sharing regime by triggering a sequence of defections that ultimately results in widespread or universal defection from the sharing regime. As illustrated in Figure 3 below, individual defections by strong and weak innovator types can give rise to two collective defection scenarios, which in turn yields corresponding shifts in the governing innovation regime. First, if a weak innovator elects *defect(copy)*, that erodes the premium accruing to original contributions and may compel a stronger innovator to select *defect(copy)*, which in turn induces a further reduction in the innovation premium, further contraction of the innovation pool, and further elections of *defect(copy)*, ultimately resulting in the standard under-innovation result. Second, if a strong innovator elects *defect(property)*, that may compel other strong innovators to elect *defect(property)* in order to protect against actual or expected increases in litigation risk, transaction costs, and input costs. That decision in turn induces further elections of *defect(property)*,⁴⁹ resulting in widespread implementation of a formal property regime, even if a sharing regime constitutes the collectively preferred outcome.⁵⁰ Interestingly, both

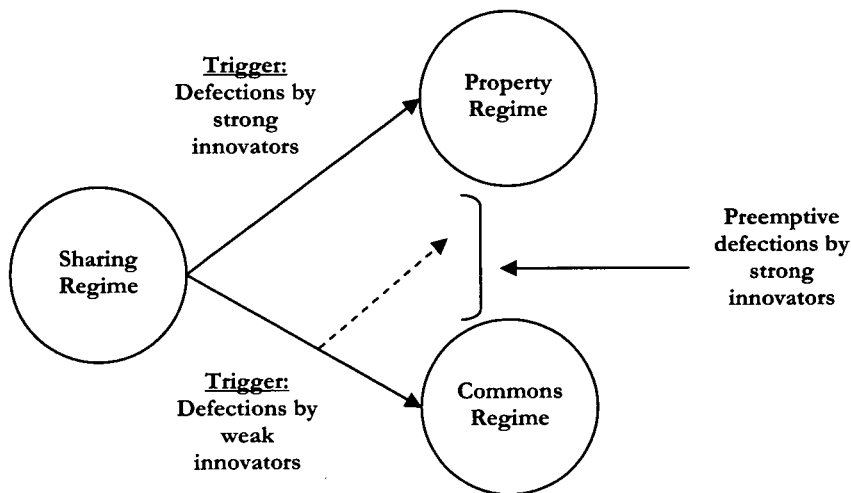
effect of heterogeneity (and group size, to the extent that heterogeneity is a positive function of group size) on private provision of public goods can be ambiguous. Specifically, under certain conditions, endowment heterogeneity can increase contribution rates where there is an increased probability that there exist extreme types who have sufficient interest and resources to unilaterally contribute to the public good independently of whether or not other contributors are doing so. See CORNES & SANDLER, *supra* note 32, at 325; Pamela E. Oliver & Gerald Marwell, *The Paradox of Group Size in Collective Action: A Theory of the Critical Mass*, 53 AM. SOC. REV. 1 (1988); Ostrom, *Types of Goods*, *supra* note 32, at 257–58. Note that this argument assumes that contributors cannot take actions to exclude non-contributing third parties from enjoying the relevant public good (i.e., cannot “convert” the public good into a private good). By contrast, the analysis above envisions that innovators can do so at some positive likelihood and some non-exorbitant cost by “activating” state-provided property entitlements (i.e., by electing *defect(property)* using the terminology introduced above), in which case substantial endowment heterogeneity can never be conducive to a high-endowment firm's incentives to contribute without making recourse to property rights.

49. For further discussion of this scenario, see Barnett, *Property as Process*, *supra* note 3.

50. Both results are sensitive to the proportions of weak, strong and other innovators in the industry. Even a substantial segment of weak innovators who elect *defect(copy)* does not

scenarios will yield the same outcome where innovators have access to a full choice set that includes *defect(property)* at some reasonable cost. Strong innovators can then preempt any underinnovation outcome, which would be triggered by *defect(copy)* elections by weak innovators. This can be accomplished by lobbying for property rights, adopting and enforcing dormant property rights, and/or adopting some other exclusionary technology. This effectively removes the *defect(copy)* option from the available choice set. Hence, as a practical matter, the three-way choice between a sharing regime, property regime, and commons regime may sometimes reduce to a two-way choice between a sharing regime and a property regime.

Figure 3: Collective Defections and Regime Shifts



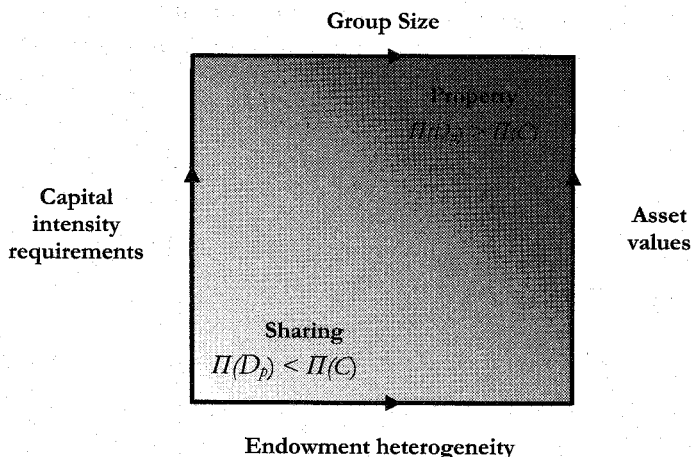
4. Predicting Cooperation

We can now consolidate this discussion into a single framework that roughly anticipates the conditions under which a sharing regime is likely to provide a stable alternative to either a commons regime or a property regime. If we assume that strong innovators can block formation of a commons regime by electing *defect(property)*, this task reduces to assessing the stability of a sharing regime relative to a property regime. Generally speaking, we can

necessarily unravel a sharing regime since the sub-population of strong innovators may rationally maximize gains by incurring the costs of complying with the governing cooperation norms, even in the face of individually rational defections by some other innovators. In the more formal language of the public-goods literature, the strong innovator population is a "privileged" or "viable" coalition playing an n -person repeated prisoner's dilemma game where the harm caused by a single violation by any individual player or sufficiently small group of players is diffused over a broad population and may therefore be insufficient to cause the *defect(property)* payoff to exceed the cooperation payoff.

expect that the stability of a sharing regime will decline as one or more of the identified variables—group size, capital intensity, economic values, and endowment heterogeneity—increases in value. Conversely, where one or more of these same variables declines in value, a sharing regime tends to become a feasible alternative. Figure 4 below summarizes graphically the proposed impact of these variables on the stability of a sharing regime.

Figure 4: Regime Determinants⁵¹



The box diagram reflects the following pair of hypotheses, which will drive discussion in the remainder of this Article.

Hypothesis 1. The most highly developed sharing arrangements, and the least developed property-rights arrangements, should exist in environments characterized by low capital investment, low economic values, and a concentrated group of relatively few (or multiple but well-organized), and substantially similar firms or other participants (denoted by the “southwest” region in Figure 4).

Hypothesis 2. The least developed sharing arrangements, and the most developed property-rights arrangements, should exist in environments characterized by high capital investment, high economic values, and a dispersed group of multiple heterogeneous firms or other participants (denoted by the “northeast” region in Figure 4).

51. For ease of exposition, this diagram assumes linear relationships between these variables; however, there is no inherent reason to believe this would be the case in any particular instance. Endowment heterogeneity may have a much stronger effect than number of innovators on the cooperation payoff relative to the defection payoff, or vice versa, in which case the “box” would be replaced by a figure drawn with substantially different proportions. Increasing coloration denotes increasing use of practices indicative of a property regime, and vice versa.

But observe the “wide open” middle of Figure 4⁵²: this designates a broad intermediate region where the market will not support undiluted property and sharing regimes. That implies two conclusions. First, a “pure” sharing regime bereft of exclusionary protections is an unexpected occurrence outside of non-capital-intensive markets that meet certain parameter conditions. Second, a “pure” property regime bereft of sharing practices is an unexpected occurrence outside of capital-intensive markets that meet certain parameter conditions. Together those two points reduce to a *third* hypothesis that this Article will pursue as it moves from hypothetical to actual sharing regimes.

Hypothesis 3. Innovation markets will typically operate subject to a mixed-form sharing regime where low-cost knowledge-exchange practices operate with property rights or other exclusionary instruments to secure innovation returns while minimizing the associated transaction-cost burdens on innovation.

IV. EMPIRICS: THE COMPLEXITY OF THE COMMONS

A theory is only as good as its ability to account for the facts it sets out to explain. I have not proposed the hypothetical sharing regime in order to identify a universally valid set of conditions under which innovation can be sustained without exclusionary barriers. That would be a fool’s errand. As a vast experimental and empirical literature can attest, there is no one-size-fits-all solution to the collective-action failure that threatens adequate provision of public goods in a wide variety of settings.⁵³ Hence, the hypothetical sharing regime is only a useful construct if it provides a tool by which to anticipate and account for actual conditions under which innovation is likely (and not likely) in typical circumstances to proceed without robust barriers against third-party imitation. This Part reviews available information on actual sharing regimes or reasonably close variants thereof,⁵⁴ which yields a

52. Note that the northwest and southeast corners of the box yield ambiguous stability expectations: in the former case, group size and endowment heterogeneity are low, favoring sharing, but asset values and capital-intensity requirements are high, favoring property; in the latter case, group size and endowment heterogeneity are high, favoring property, but asset values and capital-intensity requirements are low, favoring sharing.

53. For views to this effect, see Ostrom, *Types of Goods*, *supra* note 32 (reviewing theoretical literature on public goods problems) and Ledyard, *supra* note 48 (reviewing experimental literature on public goods problems).

54. For purposes of this exercise, a sharing regime is understood to mean any innovation market (or market segment) where a substantial portion of the relevant pool of intellectual goods is unprotected by intellectual property protections or other access limitations, whether as a formal or effective matter.

systematic (if still preliminary) taxonomy of appropriation mechanisms in innovation markets that thrive without reliance on intellectual property protections.⁵⁵

The resulting landscape of sharing regimes and related arrangements exhibits two general tendencies that largely conform to the core theoretical expectations set forth above. First, the hypothetical model of a norm-based sharing regime, which relies substantially on reputational rewards and sanctions, is largely implemented in markets that support innovative output with little reliance on formal intellectual property rights or other access barriers. Second, these substantially pure-form sharing regimes tend to be confined to markets where innovators place little capital at risk (and, even in these settings, usually make some meaningful recourse to intellectual property or other exclusionary instruments). Beyond these small-scale environments, the anticipated result is realized: the enforcement technology behind a norm-based sharing regime can no longer easily support innovation incentives and participants increasingly deploy property rights in order to block unauthorized imitation.

But there is a third observation of vital importance. Typically the emergence of a formal property regime does not entirely displace existing knowledge-sharing arrangements, which persist even in higher capital-intensity settings involving large numbers of differentially endowed participants. Following commons-styled reasoning, this fact could be interpreted to advance the proposition that intellectual production sometimes does not require access barriers. Properly construed, however, this observation substantially embellishes the standard incentive-based understanding of intellectual property and easily integrates into a long-term payoff-maximization framework. Even under a property-rights regime, repeat-player innovators seek to preserve nominal-cost mechanisms for knowledge exchange that preserve the low transaction-cost structure of a sharing regime. Remarkably, the contractual design of these embedded sharing arrangements is driven by the same reciprocity principle that drives the norm-based design of stand-alone sharing regimes, which operate without recourse to formal property rights. Through the use of property and contract to regulate access, these finely tuned sharing arrangements can scale at economically intensive settings by regulating group size and composition so as to promote satisfaction of the reciprocity principle. Regulating access in turn precludes individually rational defections that typically threaten stand-

55. For another attempt at organizing the landscape of knowledge-sharing arrangements, see Julien Penin, *Open Knowledge Disclosure: An Overview of the Evidence and Economic Motivations*, 21 J. ECON. SURVEYS 326 (2007).

alone sharing regimes unsupported by property rights. In short, sharing is most stable with property, not without it.

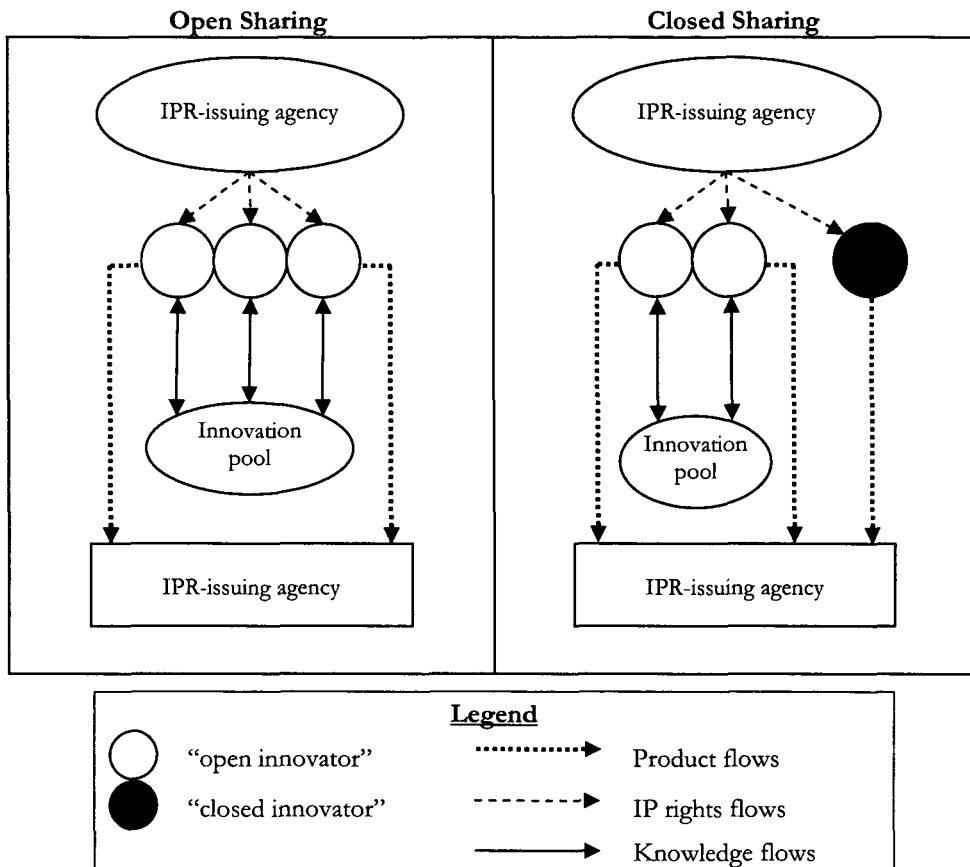
A. REGIME TAXONOMY

Tellingly, it is surprisingly difficult to locate innovation markets that implement a pure-form sharing regime where intellectual property protection is entirely absent. Hence, actual sharing regimes are best situated along an “access continuum.” This continuum ranges from “open” versions to “closed” or “semi-closed” versions. “Open” versions refer to regimes where intellectual property rights are formally available but weak, regularly waived, or otherwise largely unused, as a result of which at least some innovative output is deposited in a collective pool to which all participants have access. “Closed” or “semi-closed” versions refer to regimes that make substantial recourse to formal intellectual property rights but maintain innovation pools that are accessible to member firms subject to a mix of contractual and norm-based constraints.⁵⁶ Figure 5 below provides a graphical illustration of these two “mixed-form” sharing regimes (*open/closed sharing*), which may be usefully compared with the idealized pure-form sharing regimes (*sharing/property*) set forth earlier in Figure 1.⁵⁷

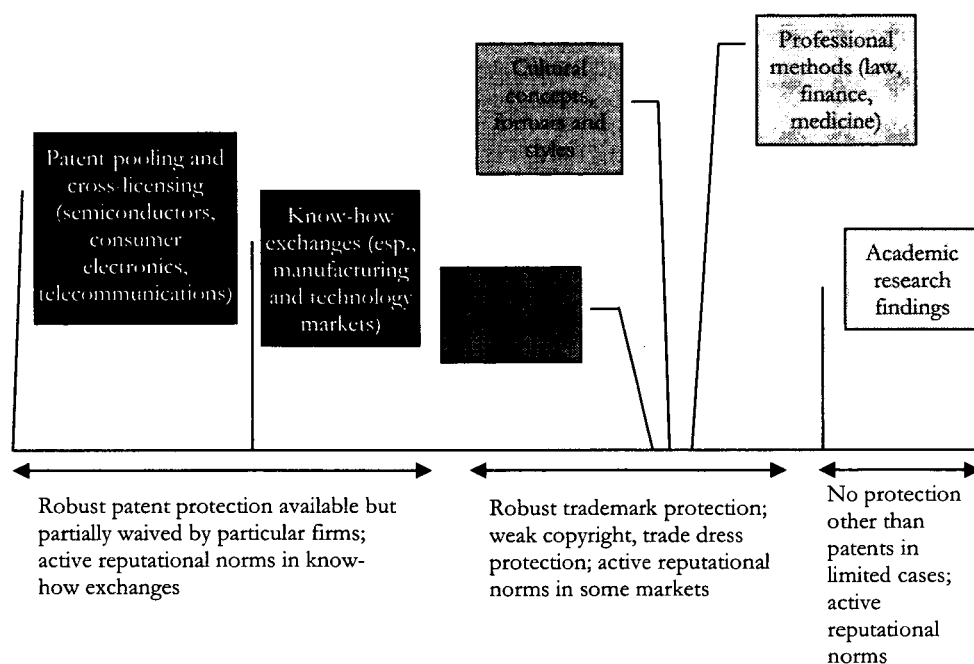
56. For a related distinction between informally organized and formally-organized knowledge-sharing mechanisms, see Penin, *supra* note 55, at 327.

57. Note that, following previous usage, “open” innovator refers to an innovator that participates in a nominal to low-cost exchange of intellectual assets; a “closed” innovator does not.

Figure 5: Alternative Regimes (Mixed Form)



This abstract distinction between closed and open sharing regimes translates as a practical matter into a graduated continuum of sharing regimes with different levels of non-negotiated third-party access, as set forth in Figure 6 below. Moving from right to left, access costs to the existing knowledge stock increase as the innovator population makes increasing use of property rights and decreasing use of the reputational reward and sanction mechanisms that support a norm-governed sharing regime. Approximately as the Figure moves from low capital-intensity markets in the research, design, professional, and cultural fields, to high capital-intensity markets in the technology and manufacturing fields, participants make greater use of property rights in general. These high capital-intensity markets make greater use of the strongest forms of intellectual property rights (moving from trademark and trade dress to copyright to patents) in particular, and lesser use of reputational norms to support innovation incentives.

Figure 6: Actual Sharing Regimes⁵⁸

The economic logic seems clear. As the innovator population (or at least, its stronger members) places greater capital at risk as a result of technological requirements, it anticipates higher expected losses in the event it incorrectly elects *cooperate* and a competitor elects *defect(copy)*. This in turn induces the strongest portions of the innovator population to act preemptively by electing *defect(property)*. Innovators abandon a norm-governed innovation regime (which can secure innovation returns at low capital intensities by recourse to reputational rewards and sanctions, to a law-governed regime). In short, increased losses in the event of expropriation justify the increased transaction-cost burdens imposed by the strongest form of legal protection.⁵⁹

58. For simplicity, this chart ignores the limited availability of patent protection for financial-method innovations, which has existed since 1998. Given the Federal Circuit's decision in *In re Bilski*, 545 F.3d 943 (Fed. Cir. 2008), and the Supreme Court's subsequent decision in *Bilski v. Kappos*, 130 S. Ct. 3218 (2010), the patentability of certain financial-method patents continues to be subject to uncertainty. Following earlier usage, increasingly dark coloration corresponds to increasing proprietization, and vice versa.

59. Scientific research (which does require substantial investment) is the exception to this relationship, which in turn accounts for the extensive subsidies provided to this market. For further discussion of this last point, see *infra* Section V.B. Note that the observed relationship does not imply that a norm-governed innovation regime could not operate at

Hence, common observations that certain low capital-intensity environments (on the right side of the spectrum) sustain innovative output, without substantial recourse to intellectual property, presumptively fail to generalize (to the left side of the spectrum) to higher capital-intensity environments, which are unlikely to induce investment in the absence of a secure barrier against third-party expropriation.

B. OPEN SHARING REGIMES

Open sharing models persist in forms substantially untouched by property rights with respect to an important set of product attributes and therefore come closest to realizing the pure-form model of a sharing regime. The most economically salient markets that fall within this category can be classified into four broad categories: (1) research—i.e., scientific and other academic research, where abstract ideas are ineligible for patent protection; (2) design—i.e., fashion and product design, where design patents, copyrights and trade dress generally offer unreliable protection for utilitarian components of any garment or industrial design;⁶⁰ (3) culture—i.e., plots, routines, formats and certain other conceptual elements used in film, television and theatrical productions, where there is weak to no protection against non-literal style and format imitation; and (4) the professions—i.e., methods or procedures used in law, finance, accounting and the medical professions.⁶¹ Legal protections against imitation in these markets are generally absent, weak, or ineffective, and, as a result, there is widespread and regular circulation of concepts, methodologies and/or designs, which are then modified and re-circulated without any remuneration flowing directly to the original contributor. Consistent with the theoretical model of a norm-based sharing regime, it should be expected that reputational rewards and sanctions would be deployed to cover the incentive shortfall generated by incomplete intellectual property coverage. This in turn ensures both a rough parity of net contributions to the innovation pool over time and a premium for original contributions over derivative applications, thereby precluding the

higher capital intensities assuming other relevant environmental variables were hospitable to it, but it tilts the odds against this possibility considerably.

60. More specifically: (1) design patent protection is usually practically ineffective given the associated delays and costs, (2) in light of *Wal-Mart Stores, Inc. v. Samara Bros., Inc.*, 529 U.S. 205 (2000), trade dress protection usually requires showing “secondary meaning,” and (3) copyright protection is unavailable for any utilitarian articles (and generally, any “conceptually inseparable” component thereof).

61. It is possible to patent medical procedures; however, this is now practically moot in light of a 1996 amendment to the Patent Code that immunizes physicians and medical facilities from liability for infringement of any medical procedure patent. There is some patent protection for financial methods, although that now is uncertain. See *supra* note 58.

under-innovation result. As described in greater detail subsequently with respect to academic research,⁶² formal and informal mechanisms for allocating inventive credit assure that original contributors accrue appropriate reputational rewards. However, in certain market segments, gross imitation triggers reputational penalties (or, to the extent trademark protections apply, legal penalties) for excessively close replications of successful originals.

A small body of scholarship documents the imitation norms that govern cultural and other market segments covered by weak or minimal intellectual property protections. These include luxury furniture design, luxury French restaurants, extreme-sports equipment hobbyists, magicians, stand-up comics, and online fan fiction contributors.⁶³ Consistent with theoretical expectations, these innovation communities tend to be relatively small in number, demand low capital investment, appear to have relatively homogenous endowments, and maintain informal mechanisms for administering reputational rewards and penalties, which in turn elicit contributions to, and regulate withdrawals from, the innovation pool. To illustrate in some more detail, consider the luxury furniture industry in Italy and the Netherlands. Designers operate with little effective protection against imitation other than unreliable copyright protections; however, they nonetheless abide by industry norms that limit excessive imitation and reward original contributions in the form of reputational credit (which is then sometimes monetized in the form of increased market premia for the most creative designers). This reputational economy is in turn facilitated by regular informal and formal communications among competing designers that can stigmatize any firm that violates these imitation norms.⁶⁴ As this market

62. See *infra* Section V.B.

63. See Emmanuelle Fauchart & Eric von Hippel, *Norm-Based Intellectual Property Systems: The Case of French Chefs*, 19 *ORG. SCI.* 187 (2008) (describing luxury French restaurants); Gerda Gemser & Nachoem Wijnberg, *Effects of Reputational Sanctions on the Competitive Imitation of Design Innovations*, 22 *ORG. STUDIES* 563 (2001) (examining Dutch and Italian luxury furniture design); Greg Lastowka, *Digital Attribution: Copyright and the Right to Credit*, 87 *B.U. L. REV.* 41 (2007) (digital forms of literary creation); Jacob Loshin, *Secrets Revealed: Protecting Magicians' Intellectual Property Without Law*, in *LAW AND MAGIC: A COLLECTION OF ESSAYS* 123 (Christine A. Corcos ed., 2007); Dotan Oliar & Christopher Sprigman, *There's No Free Laugh (Anymore): The Emergence of Intellectual Property Norms and the Transformation of Stand-Up Comedy*, 94 *VA. L. REV.* 1787 (2008) (referring to stand-up comedy routines); Rebecca Tushnet, *Payment in Credit: Copyright Law and Subcultural Creativity*, 70 *LAW & CONTEMP. PROBS.* 135 (2007) (discussing online fan fiction); Sonali K. Shah, *From Innovation to Firm Formation in the Windsurfing, Skateboarding, and Snowboarding Industries* (Univ. of Ill., Working Paper No. 05-0107, 2005), available at <http://apps.olin.wustl.edu/faculty/conferences/cresgort/pdf/6SonaliShah.pdf> (describing U.S. amateur extreme-sports hobbyists and small-business owners).

64. See Gemser & Wijnberg, *supra* note 63.

illustrates, social reward and sanctioning mechanisms can apparently substitute, at least in part, for weak intellectual property protection, and thereby induce innovation that is otherwise subject to replication. Interestingly, extensive use of honorific practices in research, design and other cultural markets may not be a sociological accident. Rather, it may be symptomatic of the fact that these markets induce innovation through the lower transaction-cost structure of a sharing regime that rewards contribution substantially through reputational rewards, as opposed to the higher transaction-cost structure of a property regime that rewards contributions primarily in monetary remuneration.

Following commons-styled thinking, it might be tempting to generalize these markets (which are certainly not short on innovation) as a paradigm case for the proposition that intellectual production typically does not require intellectual property or other access limitations. But at least one important characteristic common to all these markets immediately counsels against any such interpretation. Namely: none of these markets constitute pure stand-alone sharing regimes as envisioned in our theoretical discussion. That is, there is always some positive level of intellectual property protection available. In research markets, copyright protects against literal replication of verbal content and patent protection limits third-party usage of some applied-science findings. In design markets, trademark protects against unauthorized reproductions of name and logo (and, in non-apparel design markets, patents and trade secrets may limit unauthorized usage of other components of the relevant product). In cultural markets, trademark protects against use of name and logo and copyright protects (at least) against literal reproduction of written, visual or musical expression. In the professions, trademark protects against use of name and logo and, in finance, trade secrets (and, more recently but still to a much lesser degree, patents) may play an important role in limiting unauthorized usage of technical methods and other valuable knowledge. Moreover, even where intellectual property protections are especially minimal or ineffective, there often exist substantial levels of tacit knowledge (e.g., research methods), technological opacity (e.g., magic tricks or cuisine), associated products, services, or other business capacities (e.g., financial methods that are packaged together with the reputational capital of an established financial institution)⁶⁵ that frustrates easy or perfect imitation of the total product or services bundle provided by the original contributor. This fact is critical: if there exists some nontrivial level of exclusionary protection, whether provided legally or extra-legally, then some

65. See Peter Tufano, *Financial Innovation and First-Mover Advantages*, 25 J. FIN. ECON. 213 (1989).

product attributes are not thrown into the collective innovation pool. This precludes exact replication, and therefore allows consumers to distinguish between originators and imitators. That in turn enables the reliable operation of the attribution technology that supports the allocation of reputational awards and sanctions, which in turn generates collateral streams of monetary returns for original contributions, which in turn supports innovation investment. This is entirely consistent with the conventional incentive model! So, at best, these markets are really paradigm cases for the important proposition that intellectual production sometimes does not require a lot of intellectual property (or some practical equivalent).

In substantial conformity with theoretical expectations, this preliminary survey of open sharing markets yields a highly qualified proposition that sets strict bounds to any practical realization of the commons model. Namely, intellectual production at low capital intensities among small-number populations with substantially equivalent-value innovation endowments usually does not require strong levels of intellectual property, which is largely (but not completely) replaced by social norms that impose imperfect constraints on unauthorized imitation. This narrow proposition implies in turn that this norm-based incentive structure is unlikely to generalize to capital-intensive innovation environments, which, subject to other identified factors, therefore do require robust forms of exclusionary protection. Subject to further case-specific inquiry, social norms are unlikely to substitute adequately for intellectual property or other exclusionary protections in large-scale innovation markets characterized by high capital-intensity investments, large numbers, high endowment heterogeneity and high economic values for the relevant asset class. But this does not consign sharing mechanisms to the exotic margins of innovation markets. This proposition has an important positive implication that reserves an important place for sharing practices even in large-number and capital-intensive environments. Namely, these practices are unlikely to substitute for intellectual property, but are likely to operate as a complementary mechanism for reducing the transaction-cost burden inherent to property-rights protections.⁶⁶ Just as property has staying power even in innovation markets characterized by low levels of capital

66. Sharing arrangements and other forms of inter-firm cooperation can play other important purposes in innovation markets, including most notably, achieving gains from collective cost-sharing and risk-sharing mechanisms. For an exploration of the former possibility, see WILLIAM J. BAUMOL, *THE FREE-MARKET INNOVATION MACHINE: ANALYZING THE GROWTH MIRACLE OF CAPITALISM* Chs. 6–7 (2002); for an exploration of the latter, see Jonathan M. Barnett et al., *The Fashion Lottery: Cooperative Innovation in Stochastic Markets*, 39 J. LEGAL STUD. 159 (2010).

investment, so too do sharing practices have staying power even in innovation markets characterized by high levels of capital investment.

C. CLOSED SHARING REGIMES

Closed sharing models operate in innovation markets that (1) widely adopt intellectual property protections, (2) decline to enforce these rights with respect to knowledge exchanges with certain (usually, substantially similar peer) competitors, but (3) do enforce these rights to restrain access by other (usually, substantially dissimilar non-peer) competitors, or by any other firm, over some other class of intellectual goods. This tailored enforcement of intellectual property rights effectively constructs an innovation pool to which only member firms have access, subject to any contractual agreement as to contribution requirements, withdrawal limitations, and collateral royalty or other payments. These closed sharing arrangements are endemic in some of the most economically significant industries and appear in two forms, as broadly defined below. First, as a large social-science literature documents, geographic clusters exist (and historically existed) in crafts, industrial design, high-technology, and some manufacturing industries where rivals' employees engage in informal exchanges of technological know-how.⁶⁷ Alternatively, know-how may be embodied in fluid human capital that regularly shifts between employers.⁶⁸ These cluster formations effectively waive trade-secrecy protections over certain classes of intellectual goods in a certain segment of a larger industry (which, in some cases, otherwise does make use of patent protections).⁶⁹ Second, a wide variety of manufacturing and high-technology industries employ, or have employed, formal sharing arrangements in the form of cross-licensing or patent-pooling schemes that implement a partial

67. For an indicative reference source, see A HANDBOOK OF INDUSTRIAL DISTRICTS (Giacomo Becattini et al. eds., 2009).

68. See ANNALEE SAXENIAN, REGIONAL ADVANTAGE: CULTURE AND COMPETITION IN SILICON VALLEY AND ROUTE 128 (1994) (describing the high-technology industry in Silicon Valley and Boston area); Ronald Gilson, *The Legal Infrastructure of High Technology Industrial Districts: Silicon Valley, Route 128 and Covenants Not to Compete*, 74 N.Y.U. L. REV. 575 (1999) (describing the same subject).

69. See, e.g., Robert C. Allen, *Collective Invention*, 4 J. ECON. BEHAV. & ORG. 1 (1983) (describing blast furnace industry in 19th-century Cleveland, England); Alessandro Nuvolari, *Collective Invention During the British Industrial Revolution: The Case of the Cornish Pumping Engine*, 28 CAMBRIDGE J. ECON. 347 (2004) (describing the steam-engine industry in the mining district Cornwall, England); Eric von Hippel, *Cooperation Between Rivals: Informal Know-How Trading*, 16 RES. POL'Y 291 (1987) (describing minimills in steel industry). This is an incomplete list of know-how exchange and similar arrangements. For a discussion of some additional examples, see BAUMOL, *supra* note 66, at 86–90.

effective waiver of certain patent protections.⁷⁰ Industries using such agreements and licenses include: (1) the consumer electronics industry, which widely operates on the basis of arrangements that pool “essential patents” contributed by participating firms in connection with a variety of industry standards for fundamental audio and video compression and transmission technologies;⁷¹ (2) the biotechnology industry, which widely uses strategic technology alliances and other multi-firm cooperative research and other arrangements;⁷² and (3) the semiconductor industry, which relies on cross-licensing arrangements that provide large peer competitors with reciprocal access to an agreed-upon pool of patented assets.⁷³

A closed sharing arrangement that makes recourse to formal property rights in order to exclude non-members is substantially more stable than an open sharing arrangement that does not make use of any such exclusionary mechanism. As a result, it can induce innovation at substantially higher capital intensities. The reason is straightforward. Contract plus property rights backed up by the threat of state coercion provide a far more powerful technology for maintaining regime stability. In particular, this model presents

70. Professor Robert Merges has pioneered research in this area. See Robert P. Merges, *Contracting into Liability Rules: Intellectual Property Rights and Collective Rights Organizations*, 84 CAL. L. REV. 1293, 1340–54 (1996); Robert P. Merges, *Institutions for Intellectual Property Transactions: The Case of Patent Pools*, in EXPANDING THE BOUNDARIES OF INTELLECTUAL PROPERTY: INNOVATION POLICY IN THE KNOWLEDGE SOCIETY 123 (Rochelle Dreyfuss, Diane L. Zimmerman, & Harry First eds., 2001) [hereinafter Merges, *Patent Pools*]. I am excluding from this discussion performance rights organizations that pool copyrights relating to musical compositions (e.g., BMI and ASCAP), the reason being that these organizations simply pool copyrights in order to economize on licensing and enforcement costs and do not seek to facilitate knowledge-sharing among competing producers. Some, but not all, patent-pooling entities may share this characteristic.

71. For detailed discussion of some of these arrangements, see U.S. PATENT & TRADEMARK OFFICE, PATENT POOLS: A SOLUTION TO THE PROBLEM OF ACCESS IN BIOTECHNOLOGY PATENTS? (2000), available at <http://www.uspto.gov/web/offices/pac/dapp/opla/patentpool.pdf>; David Serafino, *Survey of Patent Pools Demonstrates Variety of Purposes and Management Structures*, KNOWLEDGE ECOLOGY INTERNATIONAL (June 4, 2007), <http://keionline.org/content/view/69/1>; and MPEG LA, <http://www.mpegla.com> (containing information regarding MPEG LA, the leading administrator of patent pools in the electronics industry). For overviews of patent-pooling arrangements in the consumer electronics and other industries, see Anne Layne-Farrar & Josh Lerner, *To Join or Not to Join: Examining Patent Pool Participation and Rent Sharing Rules* (Working Paper, 2007), available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=945189; DAVID J. TEECE, *MANAGING INTELLECTUAL CAPITAL: ORGANIZATIONAL, STRATEGIC, AND POLICY DIMENSIONS*, app. A.1.1 (2000).

72. In the biotechnology industry alone, over 20,000 alliances were reported as of 1996. See Maryann P. Feldman, *Strategic Research Partnerships in Biotechnology*, available at www.nsf.gov/statistics/nsf01336/p1s7.htm.

73. See TEECE, *supra* note 71, at app. A.

a far more powerful technology for deterring individually rational defections than the leaky technology supplied by social norms and the threat of reputational sanctions. Consistent with the incentive structure described previously, the broad extension of closed sharing arrangements across a wide variety of innovation markets follows from the fact that property rights enable participating firms to preserve stability through contractual requirements that regulate group size and endowment heterogeneity. Cross-licensing or patent-pooling arrangements use two principal instruments to regulate group composition so as to preserve regime stability. First, these arrangements usually implement access limitations that regulate endowment heterogeneity by assessing the value of firms' contributions to the collective pool. This is accomplished through an expert certification mechanism that evaluates whether any submitted patent is "essential" for the relevant technological standard.⁷⁴ Second, these arrangements often implement contractual requirements that correct for endowment heterogeneity through calibrated royalty payments that reflect substantially higher or lower-value contributions to the collective pool.⁷⁵ Additionally, governing contractual agreements limit defection opportunities into the surrounding property regime through grant-back provisions that require all members (and, typically, non-member licensees) to contribute to the pool all improvements deemed to be "essential" to the licensed technology.⁷⁶

These contractual mechanisms, as grounded in state-provided property rights, enable firms to satisfy the reciprocity principle that otherwise would dissuade participation by firms that could accrue higher gains by defecting into the surrounding property regime. The outcome: a limited number of participating firms with substantial endowment homogeneity who have little rational incentive to elect *defect(copy)* or *defect(property)*, thereby resulting in a high level of regime stability. Evidence on participation patterns in patent-pooling, cross-licensing, and know-how exchanges is consistent with this expectation: (1) firms with especially valuable technological assets sometimes opt out of participating in a patent pool (especially if a value-sensitive royalty

74. This is a typical element of patent pool agreements, especially in the consumer electronics industry. See Layne-Farrar & Lerner, *supra* note 71, at 9; Merges, *Patent Pools*, *supra* note 70, at 29–30, 34–35.

75. See Layne-Farrar & Lerner, *supra* note 71, at 3.

76. See Merges, *Patent Pools*, *supra* note 70, at 30–31, 35; see also Serafino, *supra* note 71, at 18, 22, 23, 26 (noting that MPEG-2 patent pool for video compression technology, the MPEG-4 patent pool for audio and visual compression technology, and the DVD3C and DVD6C patent pools for audio and video storage technology include grant-back commitments that all future essential patents held by licensors will be licensed back into the pool).

formula is lacking but even when it is present in some cases),⁷⁷ (2) firms are willing to enter a patent pool subject to a value-insensitive royalty formula when patent contributions are roughly symmetrical across firms,⁷⁸ and (3) in industries where even direct competitors routinely exchange proprietary know-how, firms are more likely to do so with firms who have comparably valued technology resources and often defect from the sharing norm by using property rights to safeguard the highest-value knowledge assets.⁷⁹ Moreover, formal property rights allow prospective members to safely and credibly disclose to each other endowment levels with a reduced risk of expropriation, which may be a necessary precondition to entering into a cooperative arrangement that seeks to maintain membership homogeneity in order to ensure satisfaction of the reciprocity principle.

It might be argued that this thesis does not fully characterize some multi-firm cross-licensing, standard-setting, and patent pooling arrangements, which sometimes cover a broad range of market participants with heterogeneous endowments. But this discrepancy actually reflects the stability of a closed sharing arrangement, which overcomes two vulnerabilities in an open sharing arrangement that operates without state-provided property rights. First, on the “high end” of the endowment distribution, closed sharing arrangements are able to generate a calibrated cooperation payoff that induces some participation by the strongest innovators. This occurs through tailored royalty-stream allocations and other payment mechanisms that reward exceptional contributions (sometimes complemented by allowances that permit those participants to exclude the most valuable patents).⁸⁰ Second, on the “low end,” these sharing arrangements induce some participation by weak innovators due to the exclusionary mechanisms that at least partially eliminate any anticipated defection payoff (that is, increase the cost of remaining outside the resource pool to which members can restrict

77. See Layne-Farrar & Lerner, *supra* note 71, at 3, 20–21. The authors cite the example of Lucent, who chose not to participate in the MPEG-2 patent pool, unlike most other major players in the industry, apparently on the view that it could extract greater value by licensing its especially valuable patents independently. See *id.*, at 7, 14. It turned out to be mistaken and, based on the “MPEG LA” website, is now a member. See MPEG LA, *supra* note 71.

78. See Layne-Farrar & Lerner, *supra* note 71, at 3.

79. For an indicative example, see von Hippel, *supra* note 69, who documents information sharing among competing steel “minimills” but additionally observes that an “outlier” firm declined to participate in this practice; not surprisingly, that firm appears to possess technical expertise that cannot be reciprocated by its competitors. See *id.* at 296. On further references to studies of know-how exchanges, see *supra* note 69.

80. See Merges, *Patent Pools*, *supra* note 70.

access)⁸¹ while contractual devices may be able to accommodate weak innovators without unduly eroding the cooperation payoff that flows to the existing pool of strong innovators. This is a somewhat paradoxical result: selective use of property rights (together with contract law) allows the sharing arrangement to capture the most “dangerous” lowest and highest fringes of the innovator population. While this increases endowment heterogeneity within the sharing arrangement, it decreases the defection payoff for weak innovators and increases the cooperation payoff for strong innovators. It thereby protects the cooperation payoff for “average” innovators against both weak innovators who would otherwise elect *defect(copy)*, and strong innovators who would otherwise elect *defect(property)*, which in turn could threaten the stability of the sharing arrangement.

D. SUMMARY

This Part has undertaken two tasks. First, it has provided a reasonably comprehensive taxonomy of innovation markets that maintain substantial and documented arrangements for the inter-firm exchange of valuable knowledge. Two core categories have been identified: (1) open sharing regimes characterized by knowledge exchange governed largely by social norms, and (2) closed sharing regimes characterized by knowledge exchange governed largely by multilateral contractual instruments grounded in intellectual property rights. Second, it has demonstrated that both sharing regimes substantially conform to an underlying reciprocity principle: whether through norms, contract, property rights, or some combination thereof, actually implemented sharing regimes are mixed arrangements that make extensive efforts to regulate the number and composition of the participants in any sharing arrangement. Moreover, consistent with theoretical intuitions, those access regulations increase in force and sophistication—largely as indicated by the move from norms to contract and some limited implementation of property rights—as numbers, endowment heterogeneity, capital investment and asset values increase. In the next Part, three selected markets will be studied in detail to assess further the robustness of these observations.

81. On the cost of remaining outside a technology-sharing consortium, see BAUMOL, *supra* note 66, at chs. 6–7; WILLIAM J. BAUMOL, *ENTREPRENEURSHIP, MANAGEMENT, AND THE STRUCTURE OF PAYOFFS* ch. 10 (1994). Baumol makes the important point that, in contrast to ejection from a price-setting cartel (where the ejected member can continue to profit from the supra-competitive prices set by the cartel), ejection from a technology-sharing consortium results in no benefits except to the extent there are information spillovers. This contingency obviously improves the cooperation payoff in the latter scenario.

V. CASE STUDIES: THREE ILLUSIONS OF THE COMMONS

This Part provides case studies of sharing arrangements in three disparate markets—pre-modern craft guilds, academic research, and open-source software—that are often referenced as paradigm illustrations for the commons thesis that intellectual production can proceed without limitations on access.⁸² This discussion provides the final component in the cumulative sequence of theoretical and empirical argument that I have presented to assess the reliability of the commons model for understanding innovation markets and making innovation policy. The commons model fails to reliably account for the mechanisms that support innovation even in these apparently open-access markets. This failure is consistent with both (1) theoretical expectations based on the hypothetical construct of a sharing regime, as presented in Part II, and (2) the general tendencies in actual sharing regimes, as presented in Part III. Innovation investment in these weakly propertized markets relies on, and would be unlikely to persist without, collateral instruments that restrict access and thereby generate remunerative streams to reward contributions to the innovation pool. By dispensing with any aspirational view that these markets successfully sustain (or sustained) innovative output in a free-appropriation environment unencumbered by exclusionary protections, it is possible to observe a remarkably consistent pattern in the mixed implementation of property-based and sharing-based strategies. Together these strategies generate the nuanced hybrid regimes that govern (or governed) these otherwise historically and technologically disparate markets. Remarkably, all three markets exhibit a nested mixed-form structure consisting of: a “sharing core” that enables low transaction-cost exchanges of intellectual assets among peer innovators, which is embedded within a “property perimeter” consisting of legal entitlements that enable the sharing core by regulating access and thereby preserving the conditions that support rational contributions to the innovation pool. To appreciate the analytical ground that has been covered, one may compare the complexity of these actual innovation regimes (each of which is presented graphically in Figures 7, 8 and 9 in the following discussion) with the idealized pure-form and generic mixed-form sharing regimes presented previously in Figures 1 and 5, respectively.

82. *See supra* note 8. While craft guilds in particular are not commonly referenced in support of the case that intellectual property is an unnecessary incentive mechanism, it is often asserted that intellectual production existed prior to the advent of intellectual property, which in turn is then purported to cast doubt on the case for intellectual property. *See, e.g.,* KRANICH, *supra* note 8. Craft guilds are used in this analysis as an illustrative case of pre-modern intellectual production.

A. CRAFT GUILDS

Various forms of sharing regimes appear to have been the standard governance structure for innovation markets in pre-modern Europe,⁸³ as illustrated in particular by the guilds and similar collective organizations that characterized Western European crafts industries for approximately 500 years ending in the nineteenth century.⁸⁴ The mechanisms used to regulate innovation within craft guilds, and the ultimate demise of that structure, are remarkably consistent with this Article's thesis. First, in the absence of intellectual property rights, craft guilds relied on norm-based (and technological) constraints to stimulate the production of, and regulate access to, valuable knowledge. Eventually, the norm-based mechanisms behind craft guild innovation were challenged and ultimately displaced by state-provided property rights as outside economic values, group size, and endowment heterogeneity increased.

At the cost of over-generalization, the basic structure of a craft guild was as follows: the guild was usually assigned an exclusive (or semi-exclusive) license to provide a certain product in a certain territory; the guild was empowered to enforce its regulations with respect to its members; and the guild regulated, among other things, the employment and training of apprentices and the conformity of working processes and finished products with guild standards. In place of property entitlements held by individual innovators, guilds avoided under-innovation outcomes through substantial compliance with community norms to the extent maintained by business and other social sanctions among guild members (often but not always tied

83. See Stephan R. Epstein, *Property Rights to Technical Knowledge in Premodern Europe, 1300–1800*, 94 AM. ECON. REV. 382, 383 (2004) [hereinafter Epstein, *Property Rights*] (noting that, in Western Europe, “much premodern craft and engineering knowledge appears to have been shared . . . within industrial districts”).

84. Crafts guilds (associations of artisans) and merchant guilds (associations of traders) were leading forms of economic organization in pre-modern Europe. The historical literature is vast and can only be referenced selectively. For overviews, see PAMELA O. LONG, OPENNESS, SECRECY, AUTHORSHIP: TECHNICAL ARTS AND THE CULTURE OF KNOWLEDGE FROM ANTIQUITY TO RENAISSANCE 72–101 (2001); S. R. Epstein, *Craft Guilds, Apprenticeship and Technological Change in Preindustrial Europe*, 58 J. ECON. HIST. 684, 689–90, 705–07 (1998) [hereinafter Epstein, *Craft Guilds*]; Sylvia Thrupp, *The Guilds*, in 3 THE CAMBRIDGE ECONOMIC HISTORY OF EUROPE 231 (M. M. Postan et al. eds., 1963). For an important prior contribution that explores the importance of guild institutions for intellectual property scholarship, see Robert P. Merges, *From Medieval Guilds to Open Source Software: Informal Norms, Appropriability Institutions and Innovation* (Working Paper, 2004), available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=661543 [hereinafter Merges, *Guilds*].

together by neighborhood, religious and/or kin relationships)⁸⁵ and between guilds, and as complemented further by collateral benefits in the form of collective branding, knowledge-sharing, risk-spreading, financing, and cost-sharing mechanisms.⁸⁶ Each guild adhered (or claimed to adhere) to norms that promoted mutual (albeit perhaps incomplete) disclosure of technical knowledge.⁸⁷ This disclosure norm followed the basic construct of a sharing regime, and yielded a collective pool from which members could make withdrawals and to which members could make contributions, thereby reducing the transaction costs of knowledge exchanges and the input costs of knowledge generation among individual craftsmen. Just as contemporary observers rally against the extension of patent rights as endangering commonly-held knowledge resources, English guilds advertised precisely the virtues of these informal knowledge-sharing practices in arguing against patent protection for certain mechanical inventions in the late seventeenth and early eighteenth centuries.⁸⁸ While that may appear to be a self-serving defense of monopolistic guild privileges, it can be defended as, at least in part, a good-faith attempt to preserve the low transaction-cost structure of a sharing regime against the administrative burdens of a property rights regime.⁸⁹

85. See Epstein, *Craft Guilds*, *supra* note 84, at 701. On the role of social capital in inducing compliance with guild norms, see Sheilagh Ogilvie, *Guilds, Efficiency and Social Capital: Evidence from German Proto-Industry*, 57 *ECON. HIST. REV.* 286, 286–333 (2004).

86. On these collateral benefits, see Epstein, *Craft Guilds*, *supra* note 84, at 686–88. For further discussion, see S.R. Epstein & Maarten Prak, *Introduction*, in *GUILDS, INNOVATION, AND THE EUROPEAN ECONOMY, 1400–1800*, at 1 (S.R. Epstein & Maarten Prak eds., 2007), and Ulrich Pfister, *Craft Guilds and Proto-Industrialization in Europe, 16th to 18th Centuries*, in *GUILDS, INNOVATION, AND THE EUROPEAN ECONOMY, 1400–1800*, *supra*, at 11–24.

87. See CHRISTINE MACLEOD, *INVENTING THE INDUSTRIAL REVOLUTION: THE ENGLISH PATENT SYSTEM, 1660–1800*, at 83 (1988); see also Epstein & Prak, *supra* note 86, at 18 (noting that shipwrights' guilds promoted knowledge sharing through regular meetings at which attendance was compulsory); Liliane Pérez, *Inventing in a World of Guilds: Silk Fabrics in Eighteenth-Century Lyon*, in *GUILDS, INNOVATION, AND THE EUROPEAN ECONOMY, 1400–1800*, *supra* note 86, at 232, 256–57 (noting Lyon silk guilds' ethos that encouraged the free circulation of knowledge); Thrupp, *supra* note 84, at 274 (noting that cost-reducing process innovations would be shared among members of the guild and kept secret from outsiders).

88. See MACLEOD, *supra* note 87, at 188. Guilds in other jurisdictions similarly opposed the extension of patent protection as “privatizing” common knowledge. See Epstein, *Property Rights*, *supra* note 83, at 384.

89. Professor Robert Merges views guilds as a form of “collective invention” whereby members used secrecy practices and other mechanisms to appropriate returns from innovation activities, which may have efficiency benefits that are overlooked by the conventional dismissal of the guilds as being a pure rent-seeking enterprise. See Merges, *Guilds*, *supra* note 84. On the conventional view of craft guilds (and its limitations), see Epstein & Prak, *Introduction*, *supra* note 86, at 1–2.

The commons literature sometimes makes reference to pre-modern forms of intellectual production to support the thesis that innovation can be sustained even without the expectation of monetary or other remuneration.⁹⁰ But this assumes that no exclusionary mechanisms were employed by pre-modern markets prior to the advent of formal intellectual property, an assumption that (to this author's knowledge) has received virtually no inquiry and, at least with respect to the craft guild, would be seriously misleading. The craft guild never operated as a stand-alone incentive structure as contemplated by the idealized construct of a norm-governed sharing regime. Rather, every guild operated under the protection of a state-granted exclusive license (or one of a restricted set of licenses) that protected the relevant guild against imitation by non-members, as complemented by secrecy procedures and statutory authorizations to enforce guild rules through compulsory membership and other sanctions. As shown in Figure 7 below, a guild is best viewed as a voluntarily formed sharing arrangement (denoted by the box with bolded lines) embedded within a formal property regime constituted by exclusionary entitlements allocated by the state, which in turn generated revenue streams that sustained innovation incentives for the guild as a whole. While there were few intellectual property protections at the individual level, these protections were robust at the group level. Through this modified property-rights regime, the guild avoided the transaction costs of a full-fledged property regime but, through grant of an exclusive or semi-exclusive license, encouraged innovation by permitting guild members to internalize as a collective entity some of the social gains generated by private investment.⁹¹

This statement is obviously an imperfect account of the incentive structure that supported guild innovation in the absence of robust intellectual property rights. Even where the state-granted license securely blocked entry by non-guild competitors (not universally the case),⁹² it still did not address an inherent defect that threatened the guild with under-innovation. While the guild license sustained collective incentives to innovate, it did not provide any support for individual incentives to innovate. To encourage investments

90. See *supra* note 8.

91. Obviously grant of a monopoly license may to a certain extent *depress* innovation given the absence of any potential entry threat. In particular, guilds would appear to have had an incentive to oppose labor-saving innovations, which would have eroded their competitive advantage over non-member artisans. The evidence suggests, however, that this reputation is partly undeserved. See Epstein, *Craft Guilds*, *supra* note 84, at 694–96; Ulrich Pfister, *Craft Guilds and Technological Change: The Engine Loom in the European Silk Ribbon Industry in the Seventeenth and Eighteenth Centuries*, in GUILDS, INNOVATION, AND THE EUROPEAN ECONOMY, 1400-1800, *supra* note 86, at 172; Thrupp, *supra* note 84, at 271–79. For a defense of the conventional view, see Ogilvie, *supra* note 85.

92. See Epstein, *Craft Guilds*, *supra* note 84, at 705–06; Thrupp, *supra* note 84, at 276–78.

in new process technologies or in the transfer of technical knowledge to apprentices, some further remunerative mechanism was necessary. A partial remedy for this defect (which may account for the guilds' reputation for technical conservatism)⁹³ may have been provided by the technical requirements for guild membership to the extent that they screened out weak innovators through the apprenticeship process.⁹⁴ This screening process assisted in preserving some approximate parity between contributions and withdrawals from the collective innovation pool. But this effective protection against knowledge spillovers to weak innovators still did not provide a rational incentive for a strong innovator to incur the costs of generating innovations (and transmitting innovations to apprentice labor) that would then be thrown into the collective pool with no direct remuneration for the contributing innovator. Guilds appear to have used a variety of devices to address precisely this vulnerability, including: (1) barring poaching of apprentices by guild members (which allowed each artisan to recoup his training investment);⁹⁵ (2) permitting members to extract some return on private innovations by implicitly allowing the use of secret cost-reducing technical processes provided the final product conformed to the guild standard;⁹⁶ (3) quasi-bartering schemes whereby innovative artisans exchanged secret technical improvements;⁹⁷ (4) inviting exceptional non-members in possession of technical innovation to join the guild (often in exchange for not opposing issuance of a patent);⁹⁸ (5) providing individuals with special remuneration or prizes for exceptional innovations that would then be available to guild members generally;⁹⁹ and, in certain cases, (6) even

93. See MACLEOD, *supra* note 87, at 113 (same, with respect to English guilds in particular); Epstein, *Craft Guilds*, *supra* note 84, at 693 (noting and partially contesting this impression).

94. See Epstein & Prak, *Introduction*, *supra* note 86, at 7–9.

95. See Epstein, *Property Rights*, *supra* note 83, at 383.

96. This point is emphasized in Epstein, *Craft Guilds*, *supra* note 84, at 693–95. For further discussion with respect to fifteenth-century Venetian glass-making guilds, see LONG, *supra* note 84, at 91–92 and Merges, *Guilds*, *supra* note 84, who observe that guilds sometimes allowed members to keep technical processes secret.

97. See MACLEOD, *supra* note 87, at 188.

98. See *id.* at 83–84.

99. For examples of these policies in the eighteenth-century Lyon silk-weaving industry, see Dominique Foray & Liliane Hilaire Perez, *The Economics of Open Technology: Collective Organization and Individual Claims in the "Fabrique Lyonnaise" During the Old Regime*, in NEW FRONTIERS IN THE ECONOMICS OF INNOVATION AND NEW TECHNOLOGY 239, 245 (Cristiano Antonelli et al. eds., 2006).

assisting patenting by individual members, who in turn assumed certain teaching responsibilities within the guild.¹⁰⁰

These internal regulatory mechanisms functioned to preserve the reciprocity principle that falters in any sharing community as endowment heterogeneity increases: strong innovators will rationally constrain participation in the absence of calibrated reward mechanisms that reflect exceptional contributions to the innovation pool. Consistent with theoretical expectations, erosion of the reciprocity principle posed a key threat to the longevity of any guild organization. Unless substantial parity between contributions and withdrawals among differently-endowed innovators could be assured, either by regulating entry into the guild and/or allocating compensatory side-payments to strong innovators, the latter group would rationally constrain contributions or, when feasible, defect into a state-provided property regime where appropriate remuneration for original contributions could be obtained on the open market. Several historical incidents illustrate this risk. The eighteenth century Lyon silk-weaver guilds, which both emphasized the free circulation of knowledge and operated (with state assistance) a limited quasi-patent regime for certain silk-weaving inventions, sometimes experienced disputes with the best inventors over the grant and/or terms of an “exclusive privilege” (a quasi-patent right).¹⁰¹ More generally, highly innovative guild members were sometimes bought out (that is, induced to defect) by rival jurisdictions or guilds in exchange for a one-time royalty payment (functionally equivalent to a lump-sum payment for an intellectual property right), a not uncommon occurrence as higher-value supra-regional markets developed and offered increased economic rewards for technological advances.¹⁰² Not coincidentally, the rapid growth of these lucrative markets in the early nineteenth century, and the resulting ability of talented artisans to better withdraw intellectual goods from the collective pool constituted by craft guilds, seems to have played some part in the ultimate decline of the guild institution and increased usage of the formal

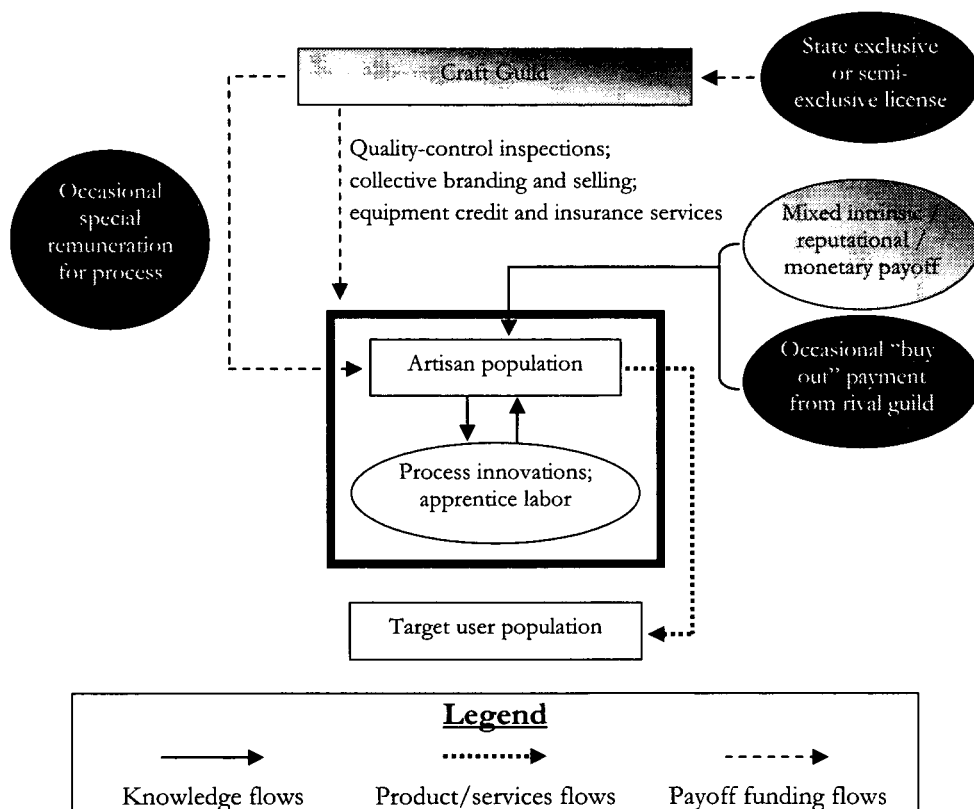
100. See Pérez, *supra* note 87, at 235–36 (making this observation with respect to the 18th-century Lyon silk weaving industry).

101. See Foray & Perez, *supra* note 99. Through state support, the eighteenth-century Lyon silk guilds maintained an early system of patent-like protection for silk-weaving inventions, which provided remuneration for inventors based largely on market success. See Pérez, *supra* note 87, at 232, 247–51, 258–59 (noting that best inventors were unhappy to operate in collective invention system that did not provide appropriate remuneration); *id.* at 262 (noting that guild system had persistent difficulty in appropriately remunerating the best inventors).

102. See MACLEOD, *supra* note 87, at 147; Epstein, *Craft Guilds*, *supra* note 84, at 703–05.

patent system.¹⁰³ Consistent with this Article's general thesis, as outside economic values, group size, and endowment heterogeneity increased, the most talented innovators rationally withheld contributions to the pool, which then stagnated. As a result, the guild institution unraveled.

Figure 7: Mixed-Form Sharing Regime (Craft Guilds)¹⁰⁴



B. ACADEMIC RESEARCH

Academic research is one of the clearest examples where intellectual production thrives in the absence of property rights. Closer scrutiny shows that it is remarkably consistent with this Article's thesis: the limited

103. See Epstein, *Craft Guilds*, *supra* note 84, at 705–07. Other commentators argue that the capital accumulation in a mature industry enabled individual merchant-manufacturers to undertake production of certain goods without recourse to the cost-sharing and risk-spreading advantages of the guild mechanism. See, e.g., Ulrich Pfister, *Craft Guilds and Proto-Industrialization in Europe, 16th to 18th Centuries*, in *GUILDS, ECONOMY AND SOCIETY* 172 (Clara Eugenia Nunez ed., 1998).

104. Consistent with prior usage, darker coloration denotes practices indicative of a property regime; lighter coloration denotes practices indicative of a sharing regime; intermediate coloration denotes mixed practices indicative of both regimes.

availability and use of intellectual property rights compels academic institutions to induce investment in research through a mix of reputational mechanisms, tax-funded subsidies and the sale of an inherently excludable product elsewhere in the consumption bundle. Namely: teaching.

Basic research results have generally not been subject to formal property-rights protection, aside from patent protection for some applied results in the hard sciences. Furthermore, in virtually all academic fields, the free exchange of research findings is a widely encouraged practice, and the hoarding of research results is a widely discouraged practice. This results in rapid dissemination of knowledge assets. These norms generate a common innovation pool from which researchers at competing institutions make withdrawals subject to attribution to the contributing author, and to which researchers make contributions in the form of research findings. Setting aside for a moment the limited availability (and even more limited use) of patent protection in some fields of scientific research, what propels researchers to invest time and effort in intellectual production even though the resulting positive externalities cannot even be partially internalized? The answer, as sociologists of science have observed, conforms precisely to the hypothetical construct of a norm-driven sharing regime. Social practices operate in virtually all disciplines to award reputational rewards that sustain output in academic research, where researchers follow openness norms. These norms mandate uncompensated forfeiture of private knowledge in exchange for the prospect of reputational prestige for innovation success, which is in turn supported by norms that mandate giving credit to prior innovators (and sanction harshly those who fail to give credit).¹⁰⁵ Reputationally driven contribution norms in the academic research market rest on a transparent and low-cost attribution technology—namely, the citation—that facilitates the fine allocation of credit among contributing researchers based on citation

105. See ROBERT MERTON, *THE SOCIOLOGY OF SCIENCE: THEORETICAL AND EMPIRICAL INVESTIGATIONS* 286–324 (1968); JEROME R. RAVETZ, *SCIENTIFIC KNOWLEDGE AND ITS SOCIAL PROBLEMS* 41–42, 245–59 (1971). For further discussion, see Partha Dasgupta & Paul David, *Toward a New Economics of Science*, 23 RES. POL'Y 487 (1994); Paul A. David, *The Historical Origins of 'Open Science': An Essay on Patronage, Reputation and Common Agency Contracting in the Scientific Revolution* 3 CAPITALISM & SOC'Y no. 2, art. 5 (2008), <http://www.bepress.com/cas/vol3/iss2/art5> [hereinafter David, *Patronage*]; Christopher Kelty, *Free Science*, in *PERSPECTIVES ON FREE AND OPEN SOURCE SOFTWARE* 415, 416–27 (Joseph Feller et al. eds., 2005); Paula E. Stephan, *The Economics of Science*, 34 J. ECON. LIT. 1199 (1996). The role of informal reputation-based norms in academic research is mentioned in the canonical work on norm-based substitutes for legal regulation, see ELLICKSON, *supra* note 21, at 59–64, 258–64.

counts, peer-review processes, and journal placement.¹⁰⁶ Reputational capital has two further benefits. First, it is a naturally compounding asset, meaning that substantial accruals of reputational capital may enable a researcher to pay the “fee” required to gain access into the most elite professional circles that discuss the most advanced methodologies or findings in the relevant field.¹⁰⁷ Second, researchers can partially monetize reputational capital in certain disciplines into higher salaries, outside publishing contracts, consulting engagements, and other material benefits.¹⁰⁸

Consistent with an open sharing model that relies heavily on reputational carrots and sticks to overcome any potential threat of excessive withdrawals from the common innovation pool, regular use of this attribution technology in conformity with the governing norm is supported by potentially severe reputational sanctions: perfect imitation without attribution (i.e., plagiarism) can result in career-ending reputational or other institutional penalties, while failure to make contributions halts further career advancement. Consistent with the sharing model, original researchers who widely disclose valuable knowledge can accrue substantial reputational rewards, allocated both through professional prestige, continuously operating mechanisms for peer review, and a wide variety of formal honors. Through this combination of market norms, and a well-developed enforcement apparatus of peer-review journals, grant-making institutions, and other entities that make appropriate allocations of reputational capital to outstanding researchers, the academic research market provides the most vivid contemporary example of an innovation pool sustained largely without recourse to state-provided property rights.

Based on these observations, it might be tempting to conclude that academic research shows that innovation can proceed without recourse to formal property rights or any other exclusionary instrument, which are

106. On attribution and reputational norms in scientific and other academic scholarship, see Rebecca S. Eisenberg, *Proprietary Rights and the Norms of Science in Biotechnology Research*, 97 YALE L. J. 177, 181–84 (1987); Catherine Fisk, *Credit Where It's Due: The Law and Norms of Attribution*, 95 GEO. L. J. 49, 64–65, 81–85 (2006); Robert P. Merges, *Property Rights Theory and the Commons: The Case of Scientific Research*, in SCIENTIFIC INNOVATION, PHILOSOPHY, AND PUBLIC POLICY 145, 148–52 (Ellen Frankel Paul et al. eds., 1996) [hereinafter Merges, *Scientific Research*]; Arti Kaur Rai, *Regulating Scientific Research: Intellectual Property Rights and the Norms of Science*, 94 NW. U. L. REV. 77, 88–94 (1999).

107. See Paul A. David, *Communication Norms and the Collective Cognitive Performance of “Invisible Colleges,”* in CREATION AND TRANSFER OF KNOWLEDGE: INSTITUTIONS AND INCENTIVES 115, 128–29 (G. Barba Navaretti et al. eds., 1998).

108. See Stephan, *supra* note 105, at 1202–03.

replaced by reputational rewards.¹⁰⁹ But this account overlooks a simple fact: academic research in any recognizable form is supported by collateral revenue streams that are excludable, which implies that researchers only partially rely on reputational payoffs in electing whether to make innovation investments. Both historical and contemporary practices in the production of academic knowledge conform to this proposition. At its inception during and shortly after the Renaissance, early forms of scientific research demanded relatively low levels of capital investment and could subsist on the monetary infusions supplied by aristocratic patrons or the independent resources of gentlemen scholars.¹¹⁰ In its modern and highly capital-intensive form, scientific research is supported by four principal revenue streams, together amounting to tens of billions of dollars annually: (1) cash grants from government agencies or large philanthropic institutions, (2) tuition payments by students, (3) alumni donations, and (4) part-time or post-career employment in the private sector. Federal research grants to academic research account for the largest component of this funding bundle. In 2007, these amounted to approximately \$28.5 billion in the United States,¹¹¹ which constituted almost 90% of total research expenditures. Scholarly commentators who advance commons-styled understandings of “pre-property” academic research generally recognize this awkward fact in passing,¹¹² but then fail to observe that it actually demonstrates that any apparently property-free model rests on either property-based appropriation

109. See, e.g., DOMINIQUE FORAY, *ECONOMICS OF KNOWLEDGE* 147 (2004) (stating that “open science model” shows that knowledge production can take place in an “IPR”-free zone, although notes that universities must rely on public funding). For similar thoughts that academic research functioned well prior to the advent of intellectual property, which is then viewed as endangering the free dissemination enabled by traditional norms in the research community, see Rai, *supra* note 106.

110. For an extensive description of these patronage arrangements, see David, *Patronage*, *supra* note 105.

111. See NAT’L SCIENCE FOUND./DIV. OF SCIENCE RESOURCES STATISTICS, *SURVEY OF FEDERAL SCIENCE AND ENGINEERING SUPPORT TO UNIVERSITIES, COLLEGES AND NONPROFIT INSTITUTIONS, FY 2007 (SEPT. 2009)*, available at <http://www.nsf.gov/statistics/nsf09315/pdf/tab1.pdf>. Note that this figure does not include state or private contributions to academic research.

112. For an example of an open-access advocate who takes this fact seriously in designing an academic “knowledge commons,” see Peter Suber, *Creating an Intellectual Commons Through Open Access*, in *UNDERSTANDING KNOWLEDGE AS A COMMONS: FROM THEORY TO PRACTICE* 171, 175–76 (Charlotte Hess & Elinor Ostrom eds., 2007). For prior contributions that recognize the importance of public funding and other capital inflows to sustain scientific research, see Merges, *Scientific Research*, *supra* note 106, at 155, and Scott F. Kieff, *Facilitating Scientific Research: Intellectual Property Rights and the Norms of Science—A Response to Rai and Eisenberg*, 95 NW. UNIV. L. REV. 691 (2001).

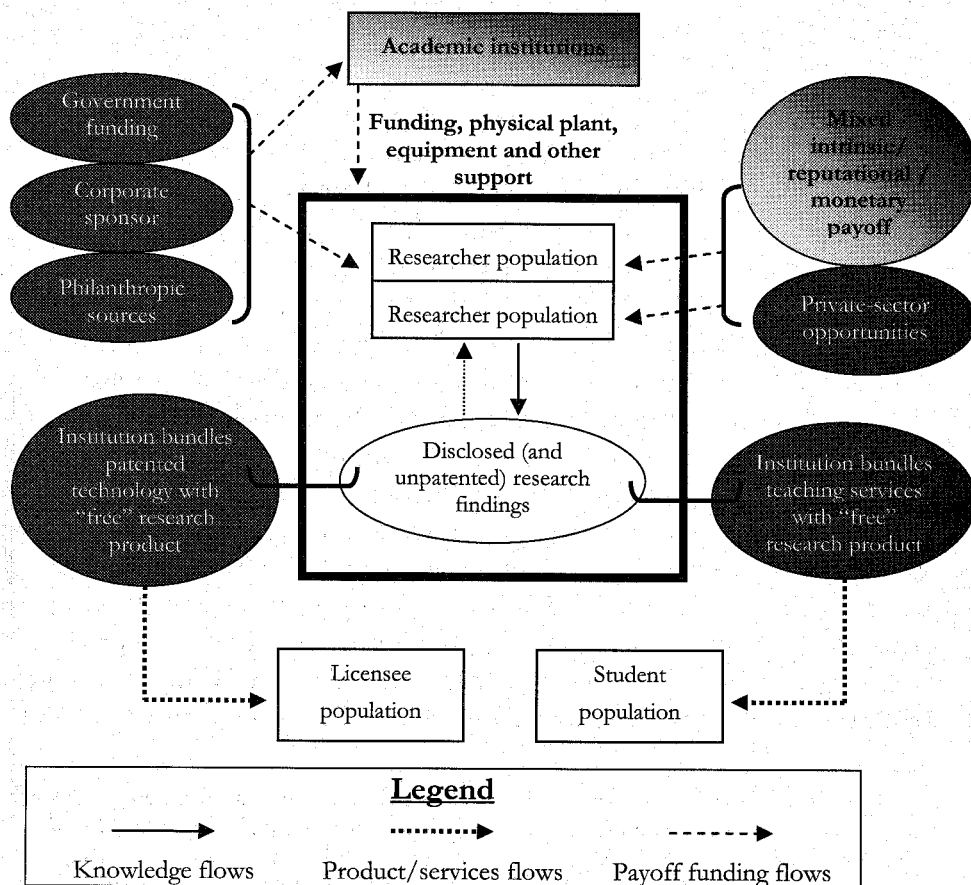
instruments, or coercive taxation to compel the necessary contributions to the public good constituted by scientific knowledge.

Properly construed, the university operates as an embedded sharing arrangement that is supported by public-goods contributions from either a coercive taxing authority (i.e., the government) and/or voluntary philanthropic institutions. The university then generates intellectual goods that can be used in three ways. First, the goods can be allied to an educational enterprise that provides an excludable good in the form of teaching services in return for which it receives an excludable stream of cash remuneration from its student clientele. Second, the goods can be “sold” on various terms to corporate partners that enter into research contracts or other forms of sponsorship with the university. Or alternatively, as enabled in part by the Bayh-Dole Act of 1980,¹¹³ which permitted universities to patent the results of federally funded research, the goods can be allied to a licensing enterprise that generates cash returns from licensees of the university’s patented technology, which is then obviously available to the collective innovation pool. So understood, the university is a knowledge-production enterprise that voluntarily participates in a sharing arrangement where it pools some intellectual goods with competing institutions for mutual advantage (represented by the “sharing core” denoted by the bolded box at the center of Figure 8 below). That is in turn funded by the proprietary sale of excludable goods to paying students, corporate sponsors, and corporate licensees. From this perspective, the university research environment looks entirely different from its standard characterization as a property-free zone that supports innovation through the publicly-interested spirit of academic pursuit. The “free” exchange of knowledge assets, which at first appears to be the key characteristic of academic research, is sustainable as a result of both (1) “internal” norm-based governance that allows for the regular allocation of reputational rewards and penalties based on a freely-exchanged body of research findings, and (2) collateral revenue streams generated by coercive redistribution (taxes), voluntary redistribution (philanthropy), and the sale of excludable assets to paying students and corporate sponsors under a conventional property-rights regime. Without these collateral revenue streams, the academic research enterprise would be compelled to migrate to a property-based model, which sustains innovation at high transaction costs (as exists in corporate research and existed in part prior to university-based

113. Bayh-Dole Act, Pub. L. No. 96-517, 94 Stat. 3019 (1980) (codified as amended at 35 U.S.C. §§ 200–211 (2000)).

academic research), or degenerate into an open-access commons, which fails to sustain innovation altogether.¹¹⁴

Figure 8: Mixed-Form Sharing Regime (Academic Research)¹¹⁵



C. OPEN-SOURCE SOFTWARE

Open-source software is one of the most widely-cited cases for the view that intellectual production can proceed and even thrive in the absence of

114. Hardly speculation: prior to the full development of the modern system of peer-reviewed scientific journals, the history of science is rife with concealment of results or partial communications of new findings in order to preserve returns from research investments, facts consistent with a modified open-access commons. See David, *Patronage*, *supra* note 105; RAVETZ, *supra* note 105, at 247–49. Based on the analytical framework set forth above, these earlier practices are easily explained: without a robust funding mechanism to close the incentive shortfall, researchers rationally declined to make valuable contributions to a shared innovation pool from which commensurate withdrawals were not forthcoming.

115. Consistent with prior usage, darker coloration denotes practices indicative of a property regime; lighter coloration denotes practices indicative of a sharing regime; intermediate coloration denotes mixed practices indicative of both regimes.

intellectual property or other access restrictions. That intuitively seems right: open-source software is defined precisely by the voluntary (if partial) disclaimer of intellectual property rights. Closer scrutiny, based largely on the extensive empirical inquiries conducted to date, shows that funding models and participation patterns tend to depart from that intuition. Consistent with this Article's thesis, open-source projects that achieve scale—that is, the most successful projects, tend to be implemented through mixed arrangements that combine giveaways of software code with the sale of complementary services and goods to institutional users and a mix of monetary, reputational and other benefits to paid and volunteer programmers.

Open-source software¹¹⁶ is an industry segment where software products and the underlying source code are released at no fee subject to relaxed contractual restrictions on use and distribution.¹¹⁷ The code is then subsequently improved by “volunteer” programmers (the reason for the quotation marks will soon become clear).¹¹⁸ In an open-source environment, the principal recourse to the state-provided property regime arises insofar as open-source software is released subject to contractual licenses. These licenses require inclusion of the developers' copyright notice (for attribution purposes), and sometimes (as in the case of the most widely-used “GNU General Public License” (GPL) license and variants thereof)¹¹⁹ obligate the user to distribute any derivative applications under the same “open source” terms as the original license, which substantially complicates the commercial distribution of derivative applications.¹²⁰ The GPL license and its variants rely

116. The scholarly literature is already extensive. For a critical overview, see Stephen M. Maurer & Suzanne Scotchmer, *Open Source Software: The New Intellectual Property Paradigm* (Nat'l Bureau of Econ. Research, Working Paper No. 12148, 2006), <http://www.nber.org/papers/w12148>. For a readable book-length overview, see STEVEN WEBER, *THE SUCCESS OF OPEN SOURCE* (2004). For a widely-known popular history, see ERIC S. RAYMOND, *THE CATHEDRAL AND THE BAZAAR: MUSINGS ON LINUX AND OPEN SOURCE BY AN ACCIDENTAL REVOLUTIONARY* (1999).

117. Source code refers to the human-readable instructions that compose a computer program. By contrast, proprietary software is released in non-human-readable object-code form (which is a translation of source code made using compiler software) for a fee and under strict contractual restrictions on use and distribution.

118. That is a simplified definition; as described below, actual market practice in the terms of open-source software licenses can vary considerably. However, the industry generally relies on an “official” definition supplied by the Open Source Initiative, which effectively sets a minimum threshold that must be satisfied by any OSI-certified license. For more information, see *The Open Source Definition*, OPEN SOURCE INITIATIVE, <http://www.opensource.org/docs/osd> (last visited Nov. 7, 2010).

119. See FREE SOFTWARE FOUND., GNU GENERAL PUBLIC LICENSE, *available at* <http://www.fsf.org/copyleft/gpl.html>.

120. Other open-source software uses the Berkeley Software Distribution (“BSD”) license or close variants thereof, which do not impose these constraints on subsequent

on contract law in order to deter individually rational defections into the surrounding property regime: it bars exclusive distribution of derivative applications of any open-source code because its drafters correctly anticipate that this would effectively constitute a withdrawal of assets from the shared innovation pool, and would ultimately undermine incentives by other innovators to make further contributions, thereby precipitating project failure.

Under any of the standard licenses, the open-source model exhibits much of the characteristics of a sharing regime. It generates a common innovation pool in the form of unprotected code, to which some developers regularly make contributions and from which other developers and end-users make withdrawals, in each case at minimal transaction costs given the voluntary waiver of most (but, critically, not all) property-rights protections. This model is a modified continuation of the informal “hacker” culture at the university computer science departments, and quasi-academic corporate research labs where a good deal of software development was initially launched, which encourages knowledge sharing and distributes reputational rewards for original contributions.

The open-source model has achieved substantial successes in certain markets, including most notably: the GNU/Linux operating system (used by some corporate and government entities), the Apache web server (which currently runs most internet websites), the Perl programming language, the SendMail internet e-mail engine (which is used to send a large portion of e-mail traffic over the internet), and the Mozilla web browser.¹²¹ In some popular, trade, business, and scholarly discussions, these successes have been used to support the claim that innovation in the software industry may be sustainable without bearing the high transaction-cost structure of a fully deployed property regime.¹²² But any account of the open-source software market as a stand alone environment that prospers without property rights or other imitation barriers seriously misunderstands the development, distribution, governance, and organizational structures at use in this market.

distributions. See WEBER, *supra* note 116, at 179–85. For a detailed description of the various types of licenses, see MARTIN FINK, *THE BUSINESS AND ECONOMICS OF LINUX AND OPEN SOURCE* (2003); LAWRENCE ROSEN, *OPEN SOURCE LICENSING: SOFTWARE FREEDOM AND INTELLECTUAL PROPERTY LAW* (2005).

121. See Ronald J. Mann, *Commercializing Open-Source Software: Do Property Rights Still Matter?*, 20 HARV. J.L. & TECH. 1, 9–10 (2006).

122. For the leading scholarly statement of this position in the legal literature, see BENKLER, *supra* note 10; Benkler, *Coase's Penguin*, *supra* note 10. For similar views, see James Boyle, *The Second Enclosure Movement and the Construction of the Public Domain*, 66 J.L. & CONTEMP. PROBS. 33, 45–46 (2003).

As can get lost in enthusiasm over what appears to be a weakly propertized but economically sustainable environment for innovation investment among a large mass of voluntary contributors,¹²³ the open-source model must confront and resolve the basic dilemma of any sharing regime: in the absence of restrictions on use and distribution (and, hence, any direct remuneration for original contributors), it must induce contributions from innovators who rationally demand returns in excess of development costs. This requires taking steps to regulate membership size and composition in any open-source project, which in turn sustains a roughly equal parity between contributions and withdrawals from the shared innovation pool (as corrected by side-payments or the equivalent thereof), thereby yielding a cooperation payoff in the form of reputational and/or monetary benefits that elicits migration from the surrounding property regime into this embedded sharing regime.

This expectation is remarkably consistent with actual practice. Open-source projects are sometimes described as mass-collaboration enterprises among hundreds to even thousands of diversely knowledgeable individual participants that somehow converge on a spontaneous order.¹²⁴ The unusually lavish scholarly attention devoted to the open-source market in its short history, however, has yielded virtually the opposite conclusion. Empirical researchers who look “behind the curtain” consistently find that open-source projects (or more precisely, the small minority of successful projects among the thousands of abandoned projects) are typically maintained by a small, core group of experienced developers (to which entry is often strictly constrained through internal control hierarchies) who exhibit high levels of technical sophistication and operate subject to reputational and other norm-governed pressures that elicit high effort.¹²⁵ For example, while

123. For a review of the literature and a similar observation, see Joseph Lampel & Ajay Bhalla, *The Role of Status Seeking in Online Communities: Giving the Gift of Experience*, 13 J. COMPUTER-MEDIATED COMM. (2007) (observing that “a fascination with the utopian aspects of virtual communities has strongly influenced research in this area,” which tends to be “highly attuned to features of virtual communities that highlight egalitarian and altruistic motivation”).

124. For the most well-known example in the popular literature, see RAYMOND, *supra* note 116, and for somewhat more nuanced versions in the legal literature, see BENKLER, *supra* note 10, at 66–67; Benkler, *Sharing Nicely*, *supra* note 10, at 332–39; Boyle, *supra* note 122, at 44–46.

125. See FINK, *supra* note 120, at 138–57; WEBER, *supra* note 116, at 70–71; Andrea Bonaccorsi & Cristina Rossi, *Why Open Source Software Can Succeed*, 32 RES. POL'Y 1243 (2003); Charles M. Schweik, *Free/Open-Source Software as a Framework for Establishing Commons in Science*, in UNDERSTANDING KNOWLEDGE AS A COMMONS, *supra* note 112, at 277, 285; see also Rishab Aiyer Ghosh, *Understanding Free Software Developers: Findings from the FLOSS Study*, in PERSPECTIVES ON FREE AND OPEN SOURCE SOFTWARE, *supra* note 105, at 23, 35 (noting

the Apache web server is used directly or indirectly by a broad pool of firms and other users, the maintenance and enhancement process is controlled by approximately twenty-five core developers, subject to formalized review and approval procedures to ensure system integrity (while larger groups of users submit “problem reports”).¹²⁶ Likely reflecting in part the disproportionate costs borne by these small groups of dedicated developers, open-source projects often fail to achieve scale beyond an initial “pioneer” effort, resulting in a high abandonment rate¹²⁷ (a fact sometimes obscured by casual references to “tens of thousands” of projects). This is an entirely unsurprising result in the case of a sharing regime that lacks an exclusionary mechanism to deliver remunerative streams that reflect differential individual contributions.

This observation still does not immediately rule out a commons-styled account of the open-source phenomenon (although high failure rates should immediately cast some doubt). This is because it fails to identify any rational support for the costly investments of time and effort even by these smaller groups of dedicated programmers in the small minority of successful projects, which therefore appear to operate on a largely or purely voluntary basis. But two further observations show this anomaly to be substantially overstated. First, there simply is no puzzle with respect to roughly half of all

that “[m]easures of source-code authorship show that a few individuals are responsible for disproportionately large fractions of the total code base” and referencing other studies that reach similar results). For membership and screening procedures as described in great detail with respect to the Debian project, see Fabrizio Ferraro & Siobhan O’Mahony, *Managing the Boundary of an ‘Open’ Project* (Harvard NOM, Working Paper No. 03-60, 2004), available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=474782 (noting that contributors to open-source projects must provide “joining scripts” to show commitment to the project and describing cryptographic and other technical tools used to regulate access to the code base), and for a similar study with respect to the Freenet project, see Georg von Krogh et al., *Community, Joining Script and Specialization: A Case Study*, 32 RES. POL’Y 1217 (2003) (describing detailed admission requirements and apprenticeship and similar training periods to regulate admission into “core” developer group).

126. See Audris Mockus et al., *Two Case Studies of Open Source Software Development: Apache and Mozilla*, in PERSPECTIVES ON FREE AND OPEN SOURCE SOFTWARE, *supra* note 105, at 163, 171–75. For similar, more general observations, see ROSEN, *supra* note 120, at 43–45. See also Bonaccorsi & Rossi, *supra* note 125, at 1247 n.10 (referencing studies of contributions to the Apache, GNOME and other active open-source projects, which show heavy concentration of contributions among core group of developers).

127. See Brian Fitzgerald, *Has Open Source Software a Future?*, in PERSPECTIVES ON FREE AND OPEN SOURCE SOFTWARE, *supra* note 105, at 93, 96–97 (noting that in a study of over 400 registered open-source projects most had two or fewer developers and the vast majority appeared to be abandoned); Mockus et al., *supra* note 126, at 187 (noting that open-source projects sometimes fail to scale because core developers cannot handle and coordinate the quasi-administrative tasks of finding and repairing defects, resulting in code of suboptimal quality).

open-source programmers, who are employed or sponsored by for-profit software incumbents or not-for-profit foundations (which are usually sponsored by for-profit companies).¹²⁸ The “half” figure is a gross understatement, however, since it counts all contributors equally. However, the most recent evidence (including a study by the Linux Foundation) shows that paid programmers are more productive than unpaid volunteer programmers—that is, they contribute more per-capita than unpaid developers.¹²⁹ This is an entirely unremarkable finding within a rational-choice framework but directly contrary to the standard altruistic model used to explain participation in open-source projects. Second, available survey evidence tends to suggest that even the residual population of unpaid programmers are motivated by a miscellany of factors, including intrinsic interest in intellectual enjoyment, need for a customized program that did not yet exist in the market, the opportunity to improve programming skills, and,

128. See Rishab Aiyer Ghosh et al., *Survey of Developers*, in *FREE/LIBRE AND OPEN SOURCE SOFTWARE: SURVEY AND STUDY* 64-65 (2002), available at http://www.flossproject.org/report/FLOSS_Final4.pdf (finding that, based on online survey of 2784 developers active in “open source” or “free source” projects, 54% receive some kind of monetary rewards for code, administrative or other contributions); Maurer & Scotchmer, *supra* note 116, at 7 (reviewing similar results); see also WEBER, *supra* note 116, at 68-69 (noting that most developers involved in open-source projects appear to come from the private-sector rather than the academic sector); GREG KROAH-HARTMAN ET AL., *THE LINUX FOUND., LINUX KERNEL DEVELOPMENT* 10-12 (2009), available at <http://www.linuxfoundation.org/publications/whowriteslinux.pdf> (finding that 70% of total code contributions to the Linux kernel came from developers who are being paid to do so by for-profit companies, including Red Hat, Google, Novell, Intel, Oracle and IBM); Karim R. Lakhani & Robert G. Wolf, *Why Hackers Do What They Do: Understanding Motivation and Effort in Free/Open Source Software Project*, in *PERSPECTIVES ON FREE AND OPEN SOURCE SOFTWARE*, *supra* note 105, at 3 (based on survey of 684 software developers, finding that 40% of the sample received direct financial compensation from employer for participation in open-source projects). Most current participants in open-source software arrangements are for-profit firms. See James Bessen, *Open Source Software: Private Provision of Complex Public Goods*, in *THE ECONOMICS OF OPEN SOURCE SOFTWARE DEVELOPMENT* 1, 6-7 (Jurgen Bitzer & Philipp J.H. Schroder eds., 2006).

129. See KROAH-HARTMAN ET AL., *supra* note 128, at 10; see also Evangelia Berdou, *Managing the Bazaar: Commercialization and Peripheral Participant in Mature, Community-Led Free Open Source Software Projects* 150 (2007) (unpublished dissertation, submitted to London School of Economics and Political Science) (based on study of GNOME and K Desktop open source projects, finding that paid developers are more likely to contribute to, and maintain, critical parts of the code base, as well as participate in community events); Jan Eilhard & Yann Ménière, *A Look Inside the Forge: Developer Productivity and Spillovers in Open Source Projects* 1, 16 (Working Paper, 2009), available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1316772 (based on panel of 10,553 open source projects registered at SourceForge during February 2005-May 2007, finding that paid corporate developers are on average more productive than unpaid academic or private developers (as measured by file releases) but that the interaction between unpaid and paid developers on the same project can cause aggregate inefficiencies).

as some researchers emphasize, reputational capital that can translate into improved career prospects.¹³⁰ The potential reputational value attached by individual contributors to participation in high-profile open-source projects is illustrated by the fact that most projects have highly detailed attribution procedures—akin to the citation technology in the academic context—to apportion reputational credit to contributing programmers.¹³¹ This is not to deny that some programmers are motivated partly by payoff-insensitive ideological or other non-instrumental considerations, but it does not appear that it can reasonably be described as the prevailing motivating factor that drives participation by most open-source programmers, or more precisely, by unpaid open-source programmers.

Even the incentive effects of reputational utility and its monetizable by-products can be overstated as the key to resolving the “open source puzzle.” It is now clear that the most economically significant portions of the open-source software segment are most accurately viewed as a mutually beneficial venture among a restricted group of participant firms dedicated to the joint development of an open-access infrastructure, which will in turn support the provision of complementary products under an allied proprietary model.¹³² It is hard to underestimate the contribution—both in terms of cash, code and, most importantly, personnel—made by proprietary software companies to facilitate the development and adoption of open source’s largest successes to date. Consider Linux, perhaps the most successful open-source application. In 2001, IBM made a \$1 billion funding commitment to Linux open-source software development (which it claims to have recouped by 2002).¹³³ That

130. For studies that emphasize reputational effects, see Eric von Hippel & Georg von Krogh, *Open Source Software and the “Private-Collective” Innovation Model: Issues for Organization Science*, 14 *ORG. SCI.* 209 (2003); Josh Lerner & Jean Tirole, *The Simple Economics of Open Source* (Nat’l Bureau of Econ. Res., Working Paper No.7600, 2000), available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=224008. Other studies are more mixed, generally finding weaker support for ideological values and stronger support for extrinsic incentives such as accrual of reputational capital and improving programming skills and intrinsic incentives such as user-based enjoyment, see, for example, Rishab Aiyer Ghosh, *Understanding Free Software Developers: Findings from the FLOSS Study*, in *PERSPECTIVES ON FREE AND OPEN SOURCE SOFTWARE*, *supra* note 105, at 23; Lakhani & Wolf, *supra* note 128. For a survey of empirical studies, see Bonaccorsi & Rossi, *supra* note 125, at 1246–50; Siobhán O’Mahony, *Guarding the Commons: How Community Managed Software Projects Protect Their Work*, 32 *RES. POL’Y* 1179 (2003).

131. See, e.g., FINK, *supra* note 120, at 28, 55; Lakhani & Wolf, *supra* note 128, at 7.

132. Elsewhere I describe in greater detail the extent to which leading open source software projects in the enterprise and mobile computing markets are substantially governed, funded and staffed by proprietary software, hardware, telecom, handset makers, and chip firms. See Barnett, *Host’s Dilemma*, *supra* note 14.

133. See Stephen Shankland, *IBM: Linux Investment Nearly Recouped*, *CNET NEWS*, Jan. 29, 2002, <http://news.cnet.com/2100-1001-825723.html>.

investment continues: today IBM employs 600 programmers at the IBM Linux Technology Center to maintain and improve the Linux operating system.¹³⁴ Together with other corporate sponsors, IBM sought to protect this investment in open-source development through the formation of (and the donation of 500 patents to) the Open Invention Network, a non-profit entity that acquires and warehouses Linux-related patents so as to preclude “hold-up” by third-party claimants.¹³⁵

The privately interested objective behind these apparently publicly interested investments is straightforward. By promoting an installed base constituted by a commoditized open-source operating system or software application (which offers an alternative to existing proprietary platform systems or applications), sponsor firms can accrue premia on proprietary applications, hardware and/or packaging, support, and documentation services that run on that base (e.g., IBM servers that run the Linux operating system).¹³⁶ Any rational choice anomaly largely disappears: each repeat-player firm incurs short-term costs (principally, losses attributable to disclosure of the source code and donated employee time and capital) in exchange for anticipated gains in the form of increased sales on complementary products and services. The practical result is reflected in the hybrid scheme set forth in the Figure below: an unprotected “sharing core” characterized by the free-exchange (and partially reputation-driven) practices typical of a sharing regime (denoted by the box in bold) is allied with complementary revenue streams on allied products and services that are protected by a legal or extralegal exclusionary instrument typical of a “conventional” property regime.¹³⁷

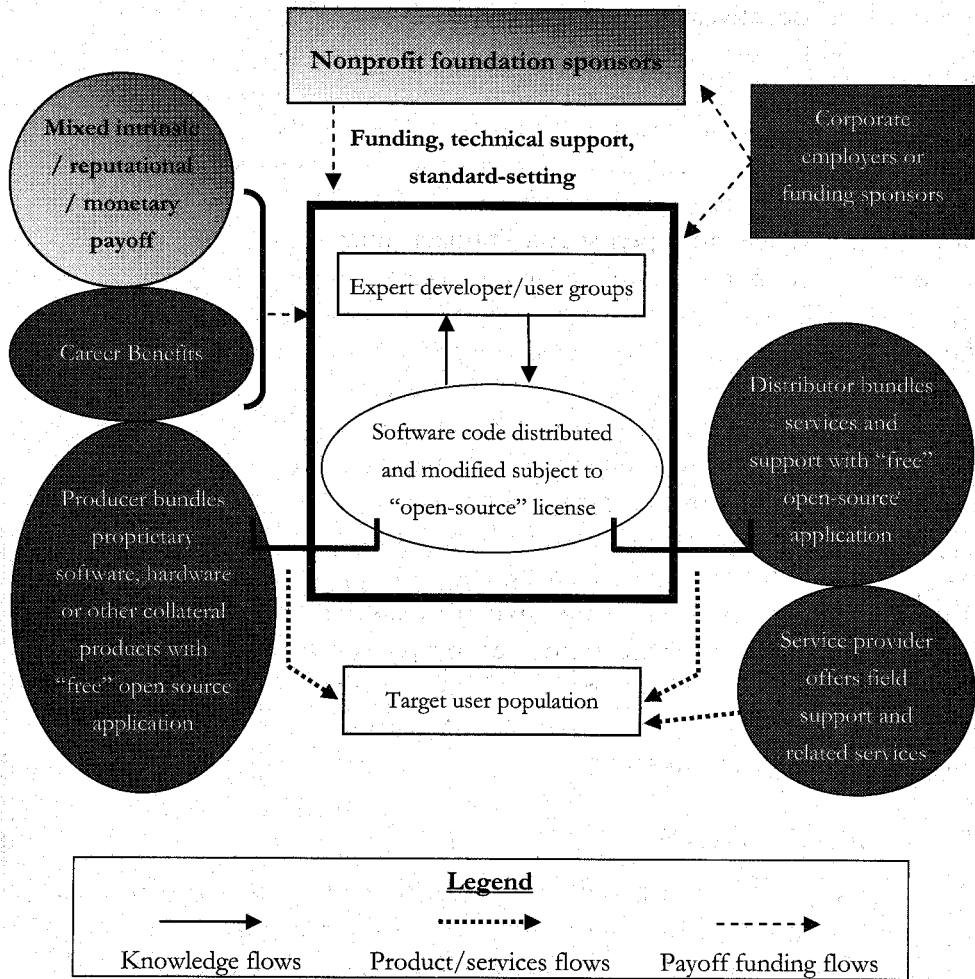
134. See David Kirkpatrick, *IBM Shares Its Secrets*, FORTUNE, Sept. 5, 2002, available at http://money.cnn.com/magazines/fortune/fortune_archive/2005/09/05/8271402/index.htm.

135. See Mann, *supra* note 121, at 29–30, 31 n.129 (2006). For further information, see OPEN INVENTION NETWORK, <http://www.openinventionnetwork.com> (last visited Nov. 7, 2010).

136. See WEBER, *supra* note 116, at 74–76; James Bessen, *Open Source Software: Free Provision of Complex Public Goods*, in THE ECONOMICS OF OPEN SOURCE SOFTWARE DEVELOPMENT 57 (Jürgen Bitzer & Philipp J.H. Schröder eds., 2006).

137. The generic taxonomy set forth in Figure 9 is a simplification of the diverse business models being deployed in the open source market. For further discussion, see FINK, *supra* note 120, at ch. 11; Joel West & Scott Gallagher, *Patterns of Open Innovation in Open Source Software*, in OPEN INNOVATION: RESEARCHING A NEW PARADIGM, 82 (Henry Chesbrough et al. eds., 2006).

Figure 9: Mixed-Form Sharing Regime (Open-Source Software)¹³⁸



The mixed-form structure of the most successful open-source projects conforms to this Article’s basic proposition. Any sharing regime that sustains economically significant investment must make recourse to the state-provided property system, or some other exclusionary instrument, in order to induce contributions. The open-source phenomenon certainly demonstrates the meaningful ability of reputational incentives (and related career benefits) to elicit certain levels of “voluntary” individual contributions to the innovation pool—a long-familiar phenomenon in academic research and

138. Consistent with prior usage, darker coloration denotes practices indicative of a property regime; lighter coloration denotes practices indicative of a sharing regime; intermediate coloration denotes mixed practices indicative of both regimes.

other “low-IP” settings. However, it equally demonstrates that, to sustain innovation projects that can scale to commercially significant levels, these reputational incentives must be accompanied by the conventional lure of monetary and other material benefits. This in turn necessitates recourse to some other legal or extralegal exclusionary instrument. Contrary to the tenor of some scholarly and trade commentary, but fully consistent with the prevailing findings in empirical research, the open-source market poses a relatively minor puzzle (if at all) for rational choice models of intellectual production. While an open-source project makes little recourse to the surrounding property regime to limit access to the innovation pool, it overcomes the free-rider threat by supplying an appropriation platform that can then generate demand for secondary products or services to which access is limited following a standard property model. As such, the open-source model is best understood as the most recent installment in an ongoing sequence of various combinations of sharing-based and property-based regimes whereby innovator populations seek to secure investment returns while minimizing the transaction-cost burdens that attend a formal property-rights regime. The true novelty of the open-source model lies in the fact that it represents a highly sophisticated tradeoff between the low transaction-cost burden of a sharing regime (mitigated by relaxed licensing of a common software platform) and the high innovation incentives of a property regime (sustained through remunerative streams from the sale of collateral proprietary products and services).

VI. CONCLUSION

In this Article, I set out to formulate and then assess a broadly representative version of a related set of positions that I group under the rubric of the commons thesis. This is understood to refer to the view that innovation markets can and do operate by recourse to reputation-driven norms in lieu of intellectual property or other exclusionary barriers. This intuition is normatively attractive and, presumptively, has some respectable factual grounding. Casual empiricism identifies innovation markets that thrive with little intellectual property and a great deal of rapid imitation; multiple case studies document the regulatory force of social norms in selected innovation markets; law-and-economics scholars and, in the common-pool resource context, political scientists and institutional economists, have documented the regulatory force of social norms (in lieu of legal instruments) in multiple settings outside of intellectual property. Sustained analysis seriously contests the reliability of this intuition. Theoretical and empirical scrutiny shows that the observation that some innovation markets apparently proceed vigorously without intellectual

property protections does not so easily yield the conclusion that economically-intensive forms of innovation can be sustained without some legal or other barrier against imitation. Basic rational-choice analysis anticipates that this norm-based model has a narrow expected scope of application: only under strict parameters is it plausible to believe that innovation will proceed without some legal or other barrier against imitation. In a certain respect, this discovery is entirely unsurprising: it is simply an extended application of the well-known claim that private contributions to a collective good in large-number settings will inevitably fail in the absence of material incentives to reward contributors and material sanctions to deter non-contributors. Empirics exhibit a tight fit with these expectations and diverge markedly from the commons thesis and its variants. A novel overview of actual sharing regimes shows that any apparently open-access environment for intellectual production either (1) tends to support economically insubstantial levels of innovation investment, or (2) actually does rely on some other exclusionary barrier, usually in connection with an allied product or service component that generates a positive remunerative stream to reward innovation. In other words: either the exception proves the rule or what appears to be the exception turns out to follow the rule after all!

This line of argument confines the scope of application of the commons thesis to small-scale or “little IP” environments characterized by low capital-intensity, low endowment heterogeneity and small group size—if, but only if, it is taken to stand for the proposition that sharing regimes can independently sustain innovation incentives without any substantial limitations on third-party access to the relevant product bundle. However, more constructively for purposes of future research, this line of argument exposes a far broader landscape of large-scale or “big IP” environments in which to expect that sharing practices will flourish as embedded mechanisms for alleviating the transaction-cost burdens that attend an extensively-deployed property regime. At least in innovation settings that demand substantial capital investments, it is of greater practical interest to adopt the following intermediate proposition: (1) sharing regimes confer substantial collective gains in the form of reduced transaction-cost burdens, but (2) outside of limited settings, are unlikely to persist unless supplemented by state-provided property rights or some other exclusionary mechanism of functional equivalence. This nuanced thesis explains both why (1) “stand alone” sharing regimes tend to be confined to low capital-intensity activities that tend to stand at the margins of economic activity, but (2) sharing practices and other nominal-cost exchange arrangements persist in embedded form in broad portions of the high-technology industries that operate at the heart of the current information-based economy. It is easy to see why the

commons model beckons so strongly. There do appear to be sharing communities that apparently sustain innovative output without robust legal barriers against imitation. However, sustained examination mostly bears out the wary intuitions of the rational choice skeptic—though not in a straightforward manner. Stand-alone sharing arrangements typically are only able to survive in low capital-intensity settings that tend to lie outside the most economically significant forms of technological and creative production; where this condition is not satisfied, these arrangements often persist in some form but are embedded within an environment secured by property rights or other access barriers.

This view might seem inconsistent with the law-and-economics literature on communities that maintain “order without law” and the social science literature on “limited-access commons regimes” that solve or ameliorate public-goods problems without recourse to state enforcement. But there is no such discrepancy. Scholars have identified settings where norms operate in lieu of law to address collective-action failures: this tends to occur in small-number communities consisting of a restricted membership of repeatedly-interacting players with similar endowments and interests (Shasta County ranchers,¹³⁹ New York diamond merchants,¹⁴⁰ and Maine lobstermen,¹⁴¹ to name a few). Not coincidentally, the most prudently constructed commons models in innovation environments are confined to low-stakes environments for cultural expression that do not require capital-intensive investments in research, production or distribution.¹⁴² These conditions are by definition unsatisfied by innovation markets of economic significance involving large numbers of differentially-endowed agents and large investment requirements, which must therefore make recourse to exclusionary instruments in order to sustain innovation incentives.

But the staying power of property in innovation markets does not banish sharing practices to the fringes of intellectual property scholarship. To the contrary: mechanisms for the low-cost exchange of intellectual goods persist at the very heart of innovation markets that widely implement intellectual

139. See ELLICKSON, *supra* note 21.

140. See Lisa Bernstein, *Opting Out of the Legal System: Extralegal Contractual Relations in the Diamond Industry*, 21 J. LEGAL STUD. 115 (1992).

141. See JAMES M. ACHESON, *THE LOBSTER GANGS OF MAINE* (1988).

142. See Lastowka, *supra* note 63 (arguing that amateur creators of original works of authorship are motivated by nonmarket considerations and that creation can be sustained without copyright protections so long as attribution norms are respected); Tushnet, *supra* note 63 (describing how individual contributions to “fandom” literature, which modifies and extends storylines in existing literary or other entertainment content, are governed by a mix of social norms and copyright protections, and suggesting that this offers a future model for user-generated cultural production).

property rights. Just as rational self-interest defeats any stand-alone sharing regime as it attempts to scale up to economically intensive settings, rational self-interest drives the formation of sharing arrangements to lower the transaction-cost burden attendant to a formal property-rights regime. Most fundamentally, property rights and sharing arrangements are not antithetical concepts. Contrary to the “new” conventional wisdom, *property rights are a complement to sharing arrangements*: that is, it is only by recourse to property rights or other exclusionary instruments that sharing arrangements can persist in economically intensive markets characterized by endowment heterogeneity, large numbers and high capital-intensity requirements. And, contrary to the “old” conventional wisdom, *sharing arrangements are a complement to property rights*: that is, it is only by recourse to sharing arrangements that innovator populations can substantially alleviate the transaction-cost burdens imposed by property rights or other exclusionary barriers.