ESSAYS

THE VALUE OF GIVING AWAY SECRETS

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INTRODUCTION

RECENT years have witnessed a quiet revolution in patent law. In growing numbers, firms elect to forego patent protection, and choose instead to publish potentially patentable research findings. The new trend is not limited to small firms; on the contrary, it extends to research powerhouses with elaborate patent portfolios. For instance, Motorola, one of the nation's leading innovators and a patent giant, has recently announced that "in coming years [it] will probably want to publish more and patent less."[1] Motorola is hardly alone. More than 1000 companies have adopted the same strategy. The leading specialized journal, Research Disclosure, publishes about 400 disclosures per month, and the number is expected to rise in the future.[2] In addition, several websites dedicated to the publication of research results have been launched.[3] These developments have even prompted some concern

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[1] Richard Poynder, On the Defensive About Invention: Patents, Fin. Times (London), Sept. 25, 2001, at 14 (quoting remarks by Helen Young, a project manager in Motorola's legal department).

[2] Id.

[3] Id. The most famous website that publishes research results is www.ip.com.

that future increases in the volume of publications will dismantle the patent system.[4]

This Essay will seek to provide a novel theory that explains the shift from patenting to unprotected publication of information. Any theory that attempts this task must explain not only why firms choose to publish, but also why they publish in a manner that makes their research findings readily available for use by their own rivals. Our theory is predicated on the counterintuitive notion that stronger patent protection may harm the inventor. In particular, we will show that broad patents may be detrimental in cumulative innovation settings, where the inventive path is marked by incremental improvements on an original invention. Cumulative innovation characterizes most industrial sectors. In cumulative innovation settings, licensing constitutes an important source of revenues for existing inventors. At the same time, the need to negotiate a license is a barrier for future inventors, who wish to produce follow-on inventions. A broad patent on the original invention forces follow-on inventors to bargain for a license under unfavorable conditions. The broad protection enables the original inventor to hold-up the cumulative inventor, thereby extracting the lion's share of the value created by the cumulative invention. At first glance, it seems that the original inventor would favor strong patent protection that enables such rent extraction. We will show, however, that often this initial intuition may be misleading.

Indeed, from an ex post perspective, the original inventor would prefer a broader patent. The ex post perspective is deceptive, however, since it presumes the existence of the cumulative invention—an existence which cannot be taken for granted. Generally, the cumulative inventor would need to sink substantial development costs before she can approach the original inventor and bargain for a license. Therefore, if a broad patent protects the original invention and, consequently, the cumulative inventor expects to be held-up in the bargaining stage, she might decide to forego the cumulative invention altogether. Critically, the breadth of the original patent determines the division of surplus between the original and

[4] See id.

cumulative inventors.[5] If the share that the cumulative inventor expects to receive does not cover her ex ante development costs, then the cumulative invention will not be developed in the first place. This result is clearly detrimental not only to the cumulative inventor, but also to the original inventor.[6]

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[5] For the influence of patent breadth (that is, the breadth of the original patent) on the division of profits between the original and cumulative innovators, see infra note 68.

[6] The hold-up problem, and its detrimental effects on potential cumulative innovation, has been recognized in the economics literature. See, e.g., Bronwyn H. Hall & Rosemarie Ham Ziedonis, The Patent Paradox Revisited: An Empirical Study of Patenting in the U.S. Semiconductor Industry, 1979–1995, 32 RAND J. Econ. 101, 102 (2001); Michael A. Heller & Rebecca S. Eisenberg, Can Patents Deter Innovation? The Anticommons in Biomedical Research, 280 Sci. 698 (1998); Roberto Mazzoleni & Richard R. Nelson, The Benefits and Costs of Strong Patent Protection: A Contribution to the Current Debate, 27 Res. Pol'y 273 (1998); Robert P. Merges & Richard R. Nelson, On the Complex Economics of Patent Scope, 90 Colum. L. Rev. 839 (1990); Arti K. Rai, Fostering Cumulative Innovation in the Biopharmaceutical Industry: The Role of Patents and Antitrust, 16 Berkeley Tech. L.J. 813 (2001) [hereinafter Rai, Fostering]; Arti Kaur Rai, Regulating Scientific Research: Intellectual Property Rights and the Norms of Science, 94 Nw. U. L. Rev. 77 (1999) [hereinafter Rai, Regulating]; Carl Shapiro, Navigating the Patent Thicket: Cross Licenses, Patent Pools, and Standard Setting, *in* 1 Innovation Policy and the Economy 119 (Adam B. Jaffe et al. eds., 2001); James Bessen, Hold-up and Patent Licensing of Cumulative Innovations with Private Information (Research on Innovation, Working Paper, 2002) (unpublished manuscript, on file with the Virginia Law Review Association); and James Bessen & Eric Maskin, Sequential Innovation, Patents, and Imitation (MIT Dep't of Econ., Working Paper No. 00-01, 2000) (unpublished manuscript, on file with the Virginia Law Review Association); see also Steven Shavell, Economic Analysis of Property Law, 8 n.217 (Nat'l Bureau of Econ. Research, Working Paper No. 9695, 2003), available at http://www.nber.org/papers/w9695 ("The second innovator, having *already* expended resources on his innovation, may not succeed through bargaining with the first in obtaining enough profit to offset his expenses. . . . Anticipating the possibly inadequate profits they will be able to secure through bargaining with first innovators, potential second innovators may decide against investing effort to make their innovations."). A similar problem occurs in the context of patent pools. In the patent pool case, the question is whether the pool agreement forces pool members to surrender to the pool any new patent that they obtain or whether pool members maintain exclusive rights to the new patent. The hold-up problem created by the latter option has prompted many pools to require automatic licensing of new patents to the pool. In fact, out of the sixty-three patent pools studied by Lerner et al., forty-six required that their members assign to the pool their future related patents that are deemed essential. See Josh Lerner et al., The Structure and Performance of Patent Pools: Empirical Evidence 39 (2003) (unpublished manuscript, on file with the Virginia Law Review Association); see also Josh Lerner & Jean Tirole, Efficient Patent Pools 38 (Nat'l Bureau of Econ. Research, Working Paper No. 9175, 2002), available at http://www.nber.org/papers/w9175 ("The provision of assigning future related patents to the pool, while having a potential anticompetitive effect may be a response to

Publication provides a mechanism for redividing the bargaining surplus between the original inventor and cumulative improvers. Instead of opting for a broader patent, the original inventor can choose to publish some part of the information that constitutes her discovery. By publishing part of her discovery, the original inventor weakens her bargaining position at the licensing negotiations stage; correspondingly, she strengthens the bargaining position of the cumulative inventor. By doing so, the original inventor commits a larger share of the ex post surplus to the cumulative inventor. Ex ante, however, this larger share induces the creation of cumulative inventions that may have not been produced otherwise.[7] Thus, by ceding some of the bargaining surplus, the original inventor increases the potential reward for cumulative inventors as well as herself.

In our model, publication maintains a critical element of the patenting process—the dissemination of new information.[8] However, while conventional wisdom views the publication that accompanies

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the possibility of future hold-up problems."); Lerner et al., supra, at 10 ("By requiring automatic licensing, the potential problem that a pool member may make an essential discovery and then demand an extraordinary sum from the other members for access to the technology is defused."). On the other hand, requiring pool members to surrender new patents dilutes the incentive to innovate. See Lerner & Tirole, supra, at 28; see also Lerner et al., supra, at 9 ("Pools encourage innovation by their members by allowing them to keep the rights to the intellectual property that they discover after the pool is formed. By requiring these awards to be assigned to the patent pool, the incentive to innovate is dulled.") (footnote omitted).

[7] The potential advantage of weaker patent protection has been demonstrated by James Bessen, supra note 6. However, Bessen treats patent strength as a policy variable, see id. at 5 ("Patent strength is determined partly by policy and partly by technical factors that vary from industry to industry."), while we consider the strategic determination of patent strength by the original inventor. Bessen and Maskin also demonstrate that initial inventors may prefer weaker patent protection in certain contexts. See Bessen & Maskin, supra note 6; see also Jerry R. Green & Suzanne Scotchmer, On the Division of Profit in Sequential Innovation, 26 RAND J. Econ. 20, 31 (1995) ("Counterintuitively, the first innovator can be better off with a narrower patent . . . ."). We discuss this conclusion further in infra note 75.

[8] This critical element of patent law is manifested in the enablement requirement (that is, the requirement that a patentee disclose the information and technology on which the patent is based). The rationale for the enablement requirement is that publicizing the information may help potential rivals of the patentee and/or sequential innovators. See William M. Landes & Richard A. Posner, The Economic Structure of Intellectual Property Law (forthcoming Nov. 2003) (manuscript at 386–87, on file with the Virginia Law Review Association). The rationale for making information public logically extends to unprotected publication.

a patent as a necessary evil for the inventor, we will argue that the original inventor will often find it in her best interest to publish the information rather than to secure patent protection for it. We will demonstrate that publication serves as a commitment device. Publishing allows the original inventor to send a credible signal that she will not try to appropriate all of the cumulative innovator's gains later and thereby encourages follow-on inventions.

Moreover, publication has the salutary effect of blazing the trail for cumulative innovators. Publication of certain aspects of a discovery may provide the impetus for subsequent improvements of the original invention. A similar effect, identified by Douglas Lichtman, explains the willingness of inventors of "platform" technologies to give away information in order to encourage others to develop applications and peripherals that would increase the overall value of the "platform" technology.[9] Thus, publication facilitates cumulative innovation, even independently of the ex post hold-up problem. Our analysis will have several important implications for patent theory and practice. First, it will call into question the standard assumption among patent scholars and practitioners that patentees always prefer to seek broad protection. We will show that when innovation is cumulative—as is almost always the case—patentees can often increase their returns by giving up some protection and publishing research results. Thus, for many inventors, less is actually more.

Second, and relatedly, we will demonstrate that narrower patents coupled with publication align inventors' profits and social welfare more closely. It is well recognized that broad patent protection in cumulative innovation settings may impede subsequent innovation and thus diminish social welfare.[10] Our analysis will sug-

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[9] See Douglas Lichtman, Property Rights in Emerging Platform Technologies, 29 J. Legal Stud. 615, 630 (2000).

[10] See, e.g., Howard F. Chang, Patent Scope, Antitrust Policy, and Cumulative Innovation, 26 RAND J. Econ. 34, 35 (1995) (focusing on "[one] of the social costs of patents: the inhibition of research and development (R&D) by other inventors with ideas for improvements in a patented product or process"); Nancy Gallini & Suzanne Scotchmer, Intellectual Property: When Is It the Best Incentive System?, *in* 2 Innovation Policy and the Economy 67 (Adam B. Jaffe et al. eds., 2001) ("A danger of IP that has been debated from its inception to the present is that IP can stifle innovation and slow progress."); Fritz Machlup & Edith Penrose, The Patent Controversy in the Nineteenth Century, 10 J. Econ. Hist. 1, 24 (1950) (discussing "the obstacles that the [patent] system put in the way of improvements by others of patented inventions");

gest that broad patents only make sense for a relatively small set of firms, under particular circumstances. Most other firms should find it in their interest to restrict their patent protection and actively encourage cumulative innovation. The appeal of narrow patents to original innovators serves to align private and social objectives on yet another dimension. The narrow patent allows for the development of partial substitutes for products based on the original discovery. The enhanced competition generated by these substitutes can be expected to increase consumer surplus and enhance social welfare.[11]

Mazzoleni & Nelson, supra note 6, at 281 ("An important consequence of the trend toward broader and stronger protection of patents, particularly in these kinds of technologies, is higher barriers to entry for new firms."); Merges & Nelson, supra note 6, at 890–91, 892–93 (observing that broad patent protection might stifle innovation: "There is good reason to believe that the Wright patent significantly held back the pace of aircraft development in the United States"; and "Radio is thus a canonical instance where the presence of a number of broad patents, which were held by different parties and were difficult to invent around, interfered with the development of the technology."); Suzanne Scotchmer, Standing on the Shoulders of Giants: Cumulative Research and the Patent Law, 5 J. Econ. Persp. 29, 37 (1991) ("[B]road patent protection could discourage the development of second generation products."). But see Edmund W. Kitch, The Nature and Function of the Patent System, 20 J.L. & Econ. 265 (1977) (arguing that broad patents stimulate further developments). Also, one strand of the literature argues that "broad patents may be efficient if ex ante contracting is available." Gallini & Scotchmer, supra, at 68; see also Green & Scotchmer, supra note 7, at 31 ("[W]e have shown circumstances in which the first patent should be broad."). There are, however, many impediments to ex ante contracting (that is contracting prior to the development of the cumulative innovation). First and foremost, if a potential cumulative innovator approaches the initial inventor with an idea for a cumulative innovation, the initial inventor may simply steal the idea. Asymmetric information introduces another significant obstacle to ex ante contracting. See Chang, supra, at 38 n.6; Gallini & Scotchmer, supra, at 68–69; Nancy T. Gallini & Brian D. Wright, Technology Transfer Under Asymmetric Information, 21 RAND J. Econ. 147, 157 (1990); Heller & Eisenberg, supra note 6, at 698; Mazzoleni & Nelson, supra note 6, at 279–80 ("If one assumes that, in general, potential licensees and patent holders have little difficulty in reaching a license agreement (that is, that the transaction costs of patent licensing are small), then one may take a relatively relaxed view of the costs of granting a large prospect controlling patent . . . . On the other hand, if one believes that transaction costs often are high, and patent holders are prone to litigation, one is less sanguine about this."); Scotchmer, supra, at 36 n.11; Bessen, supra note 6, at 2–3; Bessen & Maskin, supra note 6, at 3 (noting that post-licensing competition can prevent licensing). It should be noted that the existence of a broad patent will not always block cumulative innovation, even in the absence of ex ante contracting. See Merges and Nelson, supra note 6, at 893–94 (discussing the low royalty rates charged by AT&T for the use of the patents it held on transistor technology).

[11] See infra Part III.

Third, we will posit that the increased willingness to publish research findings is bound to enhance dynamic efficiency. The pro-publication trend guarantees that some technological and scientific information remains available to all. Thus, the recent spate of publications may serve as a counterforce to the much-lamented "anti-commons" problem, which stems from the over-appropriation of scientific know-how. Furthermore, by providing a focal point for future innovation, unprotected publications can facilitate the creation of technological standards.

The publication strategy may promote dynamic efficiency on yet another dimension. In the cumulative innovation context, the challenge is not only to induce sequential innovation, but also to ensure the development of the original invention. After all, without the initial invention there will be no cumulative innovation. The problem is that often most of the surplus from a basic discovery lies in the development of cumulative innovation. Hence, without the sequential improvements, the initial invention might never be developed.[12] By promoting cumulative innovation, the publishing strategy increases the return from investment in the initial invention, thus raising the probability that the initial discovery will be made.

Finally, we will propose a modest (yet crucial) reform in patent law. Currently, inventors are allowed to publish research findings and seek patent protection for them later, as long as they file for a patent within one year of the date of publication. The ability of inventors to patent previously published results dilutes the signal sent by publishing and is likely to ward off improvers. Patent applications are published eighteen months after filing date, and until then aspiring improvers are likely to be justifiably reluctant to rely on publications. Thus, to realize the full beneficial effect of publications, and to prevent abuse, the law should allow inventors to credibly commit not to patent research results that they first choose to publish.

The remainder of this Essay is organized as follows. Part I will lay down the foundation of a new paradigm of technological innovation, a paradigm combining elements from both the property rights and information revelation approaches to patent theory. Part II will analyze the theoretical underpinnings of this new paradigm

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[12] See infra notes 87–88 and accompanying text.

and will—by examining a detailed example of cumulative innovation—define the conditions under which narrow patents and unprotected publication emerge as the dominant strategy. Part III will explore the normative implications of the analysis and derive policy recommendations. Part IV will discuss and assess the merits of potential objections to our theory.

I. PROPERTY RIGHTS, INFORMATION, AND CUMULATIVE INNOVATION

Patent law scholars may be roughly divided into two groups: the "property rights" camp and the "information revelation" camp. Economists and legal scholars who belong in the former camp have concerned themselves primarily with the grand challenge of justifying patent protection.[13] The standard justification is that property rights in inventions are necessary to provide inventors with an incentive to innovate.[14] Absent property right protection, imitators would be able to appropriate the valuable information embodied in inventions without incurring the considerable costs of research and development.[15] In such a world, however, inventors will likely put their creative skills to rest, and too few inventions will be produced. On this view, therefore, patent protection is necessary to remedy the underprovision problem that stems from the positive externalities produced by information goods.[16] Since patent protection is not cost-free, the gist of the analysis has been to compare the positive incentive effects created by patent protection against

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[13] See, e.g., F.M. Scherer & David Ross, Industrial Market Structure and Economic Performance 621–24 (3d ed. 1990) (explaining the need for patent protection).

[14] See, e.g., Kenneth W. Dam, The Economic Underpinnings of Patent Law, 23 J. Legal Stud. 247, 247 (1994) (discussing the "appropriability problem" that arises when firms cannot recoup research and development expenses).

[15] See, e.g., Jonathan M. Barnett, Cultivating the Genetic Commons: Imperfect Patent Protection and the Network Model of Innovation, 37 San Diego L. Rev. 987, 991 (2000) (noting that "[t]he incentive theory correctly states that patent protection stimulates private investment by warding off low-cost imitators and promising monopolistic profits that will at least cover product development costs").

[16] Or, as Judge Richard Posner succinctly explained the rationale underlying the patent system, "the manufacturer . . . will not sow if he won't be able to reap." Richard A. Posner, Economic Analysis of Law § 3.3, at 38 (6th ed. 2003).

the social deadweight loss and the administrative costs generated by it.[17]

Lately, a second, albeit smaller, camp has emerged. Scholars associated with this camp have broadened the theoretical prism beyond the inventor-patentee and the need for property rights protection to induce innovation and have focused instead on the information revealing effects of patent protection on other parties. One of the co-authors of this Essay (Gideon Parchomovsky) has highlighted the ability of firms that trail in a patent race to disclose new information to the public in order to raise the prior art bar and thereby preempt the issuance of a patent to a competitor who is ahead in the race.[18] In a similar vein, John R. Thomas has proposed the use of bounties to induce the public to disclose prior art to the Patent and Trademark Office ("PTO") in order to improve the quality of the patent application review process.[19] Pushing patent theory further, Douglas Lichtman, Scott Baker, and Kate Kraus have shown that strategic disclosure is more likely to be employed by a firm leading—rather than trailing—a patent race, in order to secure its ultimate victory or to increase its expected payoff.[20] Finally, Clarisa Long has espoused the theory that patents are merely informational signals that provide firms with a credible and cost-

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[17] Merges and Nelson dubbed this body of scholarship, "the two-dimensional analysis of incentives and deadweight loss." Merges & Nelson, supra note 6, at 842. For a powerful critique of the incentive theory, see Jonathan M. Barnett, Private Protection of Patentable Goods (unpublished manuscript, on file with the Virginia Law Review Association).

[18] See Gideon Parchomovsky, Publish or Perish, 98 Mich. L. Rev. 926 (2000) (discussing preemptive publications). Several commentators have suggested that the opportunity for such preemptive publication under U.S. patent law is more limited than Parchomovsky suggests. See Rebecca S. Eisenberg, The Promise and Perils of Strategic Publication to Create Prior Art: A Response to Professor Parchomovsky, 98 Mich. L. Rev. 2358, 2358–59 (2000); Douglas Lichtman et al., Strategic Disclosure in the Patent System, 53 Vand. L. Rev. 2175, 2177–78 (2000). There is evidence, however, that the practice of preemptive publication is prevalent. See, e.g., Michael A. Cantor & Pamela S. Chestek, Defensive Disclosure as an Alternative to Patenting, Conn. L. Trib., Jan. 28, 2002, at 10 (reporting that "[m]any companies make defensive disclosures, including Xerox, the United States Army, and IBM).

[19] See John R. Thomas, Collusion and Collective Action in the Patent System: A Proposal for Patent Bounties, 2001 U. Ill. L. Rev. 305 (calling for the award of bounties to prompt opposition to patent applications at the prosecution stage).

[20] Lichtman et al., supra note 18 (unveiling the possibility of strategic disclosure by firms leading patent races and discussing the attractiveness of the strategy).

effective way of conveying information to third parties both about the invention and the firm itself.[21]

Curiously, the two scholarly perspectives seem to coexist as though they are not related.[22] Yet, they are related, and in a very profound way. Moreover, neither perspective provides an adequate explanation for the recent trend of publications of research results by firms with elaborate patent portfolios. Our goal in this Essay is to provide a unifying framework that merges the two competing scholarly prisms into one comprehensive theory. The new outlook we offer also explains why firms may prefer to publish innovative research and development ("R&D") results that could otherwise be patented.

As our starting point, we use one of Kenneth Arrow's insights, widely known as the "information paradox."[23] Arrow famously noted that without patent protection, inventors are put in a bind: In order to be able to license their inventions to third parties, inventors must disclose the nature of their innovation, but once they do, they have nothing left to license.[24] Information—the perennial public good—can no longer be fully controlled by the original inventor once it is disclosed.[25] Patents, like other property rights, internalize

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[21] See Clarisa Long, Patent Signals, 69 U. Chi. L. Rev. 625, 636–37 (2002) (presenting the signaling theory of patents).

[22] For example, in setting the stage for her theory of patents as signals, Long simply brackets out the property rights perspective. See id. at 637.

[23] Kenneth J. Arrow, Economic Welfare and the Allocation of Resources for Invention, *in* The Rate and Direction of Inventive Activity: Economic and Social Factors 609 (Nat'l Bureau of Econ. Research ed., 1962).

[24] Id.

[25] Thomas Jefferson has commented on the public good characteristics of intellectual property:

> If nature has made any one thing less susceptible than all others of exclusive property, it is the action of the thinking power called an idea, which an individual may exclusively possess as long as he keeps it to himself; but the moment it is divulged, it forces itself into the possession of every one, and the receiver cannot dispossess himself of it. Its peculiar character, too, is that no one possesses the less, because every other possesses the whole of it. He who receives an idea from me, receives instruction himself without lessening mine; as he who lights his taper at mine, receives light without darkening me. That ideas should freely spread from one to another over the globe, for the moral and mutual instruction of man, and improvement of his condition, seems to have been peculiarly and benevolently designed by nature, when she made them, like fire, expansible over all space, without lessening their density in any point, and like the

the positive externalities flowing from inventions and allow the inventor to license the invention to third parties.[26]

The existence of patent protection enables firms to derive value from inventions in three different ways. The first is self-use: The inventing firm can utilize its innovative technology to lower its production costs and thereby gain a competitive advantage. Of course, firms can take advantage of cost-reducing technologies they devise even without patent protection,[27] yet the availability of the latter lowers the cost of protecting the technology against appropriation by competitors. The second way by which firms derive value from patents is by selling the patented product. The sales method is very common in the pharmaceutical industry. Pharmaceutical companies derive the majority of their profits from selling patented drugs to consumers. The third and final way is by technology licensing. This strategy gives the inventing firm the ability to extract payment from other firms that wish to use the innovative technology either to lower their own production costs or to devise improvements on the original invention. According to a recent report, "companies are more willing than ever before to buy rights to knowledge,"[28] and, in 1998 alone, "U.S. companies earned $100 billion from licensing fees."[29]

This implies that, in many industries, the value firms derive from successful R&D critically depends on the potential for follow-on, or cumulative, innovation. Innovation is cumulative when new inventions rely on preexisting ones; it is discrete when advancements in technology are independent of previous innovation.[30] Importantly, cumulative innovation is omnipresent, and far more com-

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> air in which we breathe, move, and have our physical being, incapable of confinement or exclusive appropriation.

Graham v. John Deere Co., 383 U.S. 1, 8 n.2 (1966) (quoting 6 Writings of Thomas Jefferson 180–81 (Wash. ed. 1903)).

[26] See Harold Demsetz, Toward a Theory of Property Rights, 57 Am. Econ. Rev. 347, 359 (1967).

[27] For example, they may rely on trade-secrecy. See generally Robert G. Bone, A New Look at Trade Secret Law: Doctrine in Search of Justification, 86 Cal. L. Rev. 241 (1998) (discussing trade secrets protection as an alternative to patent law).

[28] Edward Kahn, Recognizing and Licensing IP: Why It's Important for Small Companies, The Intell. Prop. Strategist, Dec. 2000, at 8, 8.

[29] Id.

[30] Examples of industries in which innovation is discrete include toys and consumer goods packaging. See Merges & Nelson, supra note 6, at 880–81.

mon than discrete advancements. As Suzanne Scotchmer observed, "[m]ost innovators stand on the shoulders of giants, and never more so than in the current evolution of high technologies, where almost all technical progress builds on a foundation provided by earlier innovators."[31] Cumulative innovation is the hallmark of high-tech industries such as computer software,[32] semiconductors,[33] molecular biology,[34] and pharmacology.[35] It is of crucial value with respect to "platform" technologies.[36] Cumulative innovation is not limited to the high-tech sector, however. More traditional industries, such as automobiles and aircraft, are also characterized by cumulative innovation,[37] and the chemical industry displays "attributes of both discrete and cumulative models."[38]

Cumulative innovation comes in four varieties: (1) improvements of preexisting innovations; (2) cost reductions for producing existing products; (3) new applications of earlier technologies; and (4) enabling technologies such as research tools.

Some instances of cumulative innovation represent incremental improvement over preexisting inventions. A case in point is the R&D model of Sepracor, a pharmaceutical company from New England. Sepracor's scientists study big-selling drugs with significant side-effects that are approaching the end of their patents. They then remove the side-effects, and Sepracor patents the results.[39] In other settings, cumulative innova-

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[31] Scotchmer, supra note 10, at 29.

[32] See, e.g., Julie E. Cohen & Mark A. Lemley, Patent Scope and Innovation in the Software Industry, 89 Cal. L. Rev. 1, 5 (2001) (pointing out that the software industry "is characterized by rapid sequential innovation").

[33] See Bronwyn H. Hall & Rose Marie Ham, The Patent Paradox Revisited: Determinants of Patenting in the U.S. Semiconductor Industry, 1980–94, at 23 (Nat'l Bureau of Econ. Research, Working Paper No. 7062, 1999), available at http://www.nber.org/papers/w7062.

[34] Scotchmer, supra note 10, at 29.

[35] Id.

[36] See Lichtman, supra note 9.

[37] See Merges & Nelson, supra note 6, at 880–81 (noting cumulative innovation in the automobile and aircraft industries); see also Jacob A. Vander Meulen, The Politics of Aircraft 19 (1991) (detailing the patent history of the early aviation industry).

[38] Michael A. Carrier, Unraveling the Patent-Antitrust Paradox, 150 U. Pa. L. Rev. 761, 830 (2002).

[39] Bulls, Pills and Patents, Economist, June 28, 1997, at 69, 69.

tion can lead to path-breaking results: A famous historic example is the evolution of the railroad industry.[40]

While commentators have noted the ability of initial inventors to suppress follow-on innovation by refusing to license their technologies,[41] they have largely ignored the reverse possibility of initial inventors opting to facilitate subsequent innovation. Two important exceptions are the work by Robert Merges on patent pools[42] and the work by Lichtman on "platform" technologies.[43] Patentees face a strategic choice: They can either take full advantage of the exclusivity bestowed upon them by refusing to license their inventions, or they can encourage rivals to incorporate the patented technologies into subsequent innovation by licensing liberally. The cost of the former strategy is that it spurs competitors to come up with rival technologies that may eventually co-opt the initial invention;[44] the cost of the latter is that it makes it easier for licensees to beat the initial patentee in races for subsequent improvements.

The power of the recent ascent of the open source (or free) software movement amply demonstrates the appeal of inclusive property regimes.[45] Despite its title, the free software movement is predicated on traditional modes of intellectual property protec-

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[40] See generally Jacob Schmookler, Invention and Economic Growth (1966) (analyzing the effects of economic growth on technology through inventions).

[41] See, e.g., Merges & Nelson, supra note 6, at 865–68, 884–93 (discussing the problems of holdup rights and broad pioneer patents).

[42] See Robert P. Merges, Contracting into Liability Rules: Intellectual Property Rights and Collective Rights Organizations, 84 Cal. L. Rev. 1293, 1319–23 (1996).

[43] See Lichtman, supra note 9, at 615–16, 630.

[44] For example, as economist Paul Romer has noted, "the knowledge-based economy spawns quasi-monopolies such as Microsoft, but if we keep patents and copyrights limited, the Microsofts get their inevitable comeuppance. They get overtaken by somebody else in a process of 'creative destruction.'" Bernard Wysocki Jr., Wealth of Notions: For This Economist, Long-Term Prosperity Hangs on Good Ideas, Wall St. J., Jan. 21, 1997, at A1. The term "creative destruction" originates with Joseph Schumpeter, who used it to describe the process by which new technologies replace older ones. See Joseph A. Schumpeter, Capitalism, Socialism, and Democracy 83 (Harper & Row 3d ed. 1950) (1942).

[45] See generally Yochai Benkler, Coase's Penguin, or, Linux and the Nature of the Firm, 112 Yale L.J. 369 (2002) (discussing the free software movement and its implications for traditional economic models of production).

tion: namely copyright[46] and, to a lesser extent, patent.[47] The proprietors of the code, however, have chosen to exercise their intellectual property rights to cultivate a culture of sharing and free access. The GNU General Public License ("GPL"), under which many free software projects are distributed, employs a dual mechanism for enforcing compliance with community norms.[48] First, the original creator retains the copyright to the initial code, the core around which improvements are formed. Second, it allows others to use, adapt, and redistribute the code subject to the terms of the GPL,[49] which mandates free access. If a licensee attempts to defect and exclude others from her improvement, "the authors or their assignees may enforce [the inclusive terms of the GPL] through [a copyright or patent] infringement action."[50]

Although mainstream innovation displays a much higher degree of exclusion, the free software movement provides an important reference point for our analysis. The "phenomenal success" of the free software movement[51] teaches that reducing the cost of access

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[46] See David McGowan, Legal Implications of Open-Source Software, 2001 U. Ill. L. Rev. 241, 245 (2001) ("Although the agreements that define open-source code are sometimes said to create de facto property rights or 'covenants running with the code,' these agreements in fact create a nonexclusive permission to use the code subject to certain conditions. The relevant property right is copyright, which does run with the code, which is why the permissions granted by the licenses must run with the code as well.").

[47] Yodaiken Unveils RTLinux Patent License, at http://www.linuxdevices.com/news/NS4426144266.html (Jan. 30, 2001) (on file with the Virginia Law Review Association) (explaining the licensing procedure for a proprietary version of Linux); see also Real-time Linux Is Patented, Linux Weekly News (Feb. 10, 2000), at http://old.lwn.net/2000/0210 (on file with the Virginia Law Review Association) (noting that the patent license allows users to run a proprietary version of Linux "free and clear," but enforcing patent rights when users seek to distribute non-open software add-ons). The full text of the RTLinux Open Patent License, version 2.0, is available at http://www.fsmlabs.com/products/rtlinuxpro/rtlinux_patent.html (last accessed Aug. 15, 2003) (on file with the Virginia Law Review Association).

[48] See McGowan, supra note 46, at 255 (describing the "two-pronged strategy for enforcing community norms. The first is to have the original author retain the copyright in the author's code. The second is to allow others to use, modify, and redistribute the code only if they agree to comply with the GPL's terms").

[49] See GNU General Public License, at http://www.gnu.org/copyleft/gpl.html (last accessed Aug. 15, 2003) (on file with the Virginia Law Review Association) (explaining in the preamble the terms connected to redistribution of software code); see also McGowan, supra note 46, at 255 (explaining the GPL).

[50] McGowan, supra note 46, at 255.

[51] See Benkler, supra note 45, at 371.

for follow-on innovators may dramatically increase the likelihood of improvements and broad market adoption. This insight applies with equal force to more traditional innovations. A case in point is the Cohen-Boyer patent on gene splicing.[52] Having generated upwards of $155 million,[53] the Cohen-Boyer patent is considered one of the most valuable patents in history. The immense success of the patent is due, in large part, to the inventors' decision to ensure wide dissemination of the technology by charging an extremely low licensing fee of $10,000. Consequently, even companies that would normally run the risk of infringing elected to license the patent.[54] The wide licensing strategy was clearly "a boon to the public"; however, it also greatly benefited Stanford and the University of California, to whom the patent was assigned.[55]

At first glance, facilitation of cumulative innovation may seem perfectly consistent with broad patent protection of the initial invention. This broad protection allows the initial patent holder to choose between exclusion and facilitation. In particular, the patent holder may opt for facilitation via low licensing fees whenever such a strategy is privately optimal.

This apparent appeal of broad intellectual property ("IP") protection is misleading, however, because it will often be difficult for the owner of a broad patent to credibly commit to charging a low fee from prospective cumulative innovators. Such a commitment is necessary to induce cumulative innovation whenever the sequential improver must sink substantial investment before negotiating the license fee. Not having committed to a low licensing fee, the initial inventor will be tempted to charge a high fee after the cumulative inventor has invested heavily in the improvement and is, therefore, at the mercy of the initial inventor.[56] Anticipating such an ex post

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[52] U.S. Patent No. 4,740,470 (1988); U.S. Patent No. 4,468,464 (1984); U.S. Patent No. 4,237,224 (1980).

[53] Kenneth Sutherlin Dueker, Biobusiness on Campus: Commercialization of University-Developed Biomedical Technologies, 52 Food & Drug L.J. 453, 492 tbl.12 (1997).

[54] Id. at 495.

[55] Peter Mikhail, Note, *Hopkins v. CellPro*: An Illustration that Patenting and Exclusive Licensing of Fundamental Science is Not Always in the Public Interest, 13 Harv. J.L. & Tech. 375, 382 (2000).

[56] This hold-up problem is discussed further below. See infra Part II.

hold-up, many potential improvers will be reluctant to invest in cumulative innovation.[57]

This cost of broad patent protection helps reconcile the common view that strong patent protection hinders cumulative innovation[58] with the claim that the owner of a broad patent can simply set a low license fee. Strong patent protection, by making it difficult to secure an ex ante commitment to a low licensing fee, hinders cumulative innovation by deterring subsequent innovators.[59] This cost of broad patent protection suggests the potential superiority of an alternative strategy—narrow patents coupled with unprotected publication.[60]

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[57] See infra Part II. Admittedly, it is not always the case that sequential innovators must invest significant amounts prior to negotiating the licensing agreement. For instance, in the case of research tools, such as the Cohen-Boyer patent, it is likely that substantial ex ante investment will not be required. See infra note 60 (observing that in certain specific cases, an initial patent holder can commit to setting a low licensing fee, even with a broad patent).

[58] See, e.g., Kenneth W. Dam, The Economic Underpinnings of Patent Law, 23 J. Legal Stud. 247, 253 (1994) (noting that broad patents can inhibit future innovation); Merges & Nelson, supra note 6, at 884–93 (discussing the adverse effects of broad pioneer patents on subsequent innovation in the electrical lighting, automobile, airplane, and radio industries); Rai, Fostering, supra note 6, at 831–38 (providing examples of how patent protection can stymie cumulative research in biotechnology); Bessen & Maskin, supra note 6 (manuscript at 3–4) (finding that empirical evidence and theory both demonstrate that strong patent protection of computer programs lessens innovation). The most famous historical example is Thomas Edison's broad patent on the use of carbon filament as a source of light and its hindrance of innovation in the field of incandescent lighting. The Edison Electric Light Company did very little to improve on the invention, yet used the patent to smother competitors who came up with follow-on improvements. See Arthur A. Bright, Jr., The Electric-Lamp Industry: Technological Change and Economic Development from 1800 to 1947, at 91–93, 122–39 (1949).

[59] Alternatively, the view that strong patent protection hinders cumulative innovation can be explained by a divergence between the private interests of the initial patent holder and the social objective of promoting cumulative innovation. It may be argued that while the owner of a broad patent can theoretically set a low licensing fee and facilitate sequential improvements, she may choose exclusion over facilitation if it will secure a greater private payoff. We demonstrate, however, that the divergence between private interests and social objectives is not as deep as conventionally believed. See infra Parts II and III.

[60] In certain specific cases, the initial patent holder may be able to commit to setting a low licensing fee, even with a broad patent. Such a possibility may arise when the initial patent holder is a repeat player dealing with many similarly positioned sequential innovators. Under those circumstances, the initial patent holder may be able to develop a reputation for charging low licensing fees. This may have been the case with the Cohen-Boyer patent. The open source movement similarly has been successful in

The conventional wisdom assumes that *all* patentees would always want the broadest patents they can obtain.[61] There is, however, no reason why this should be true. Recognizing the tradeoff between the current advantage of broad protection and the future advantage of profits from cumulative innovation, some initial patentees should be expected to cede some protection voluntarily in order to increase their revenues from licensing.

The analysis so far has demonstrated that sensitivity to cumulative innovation and ex post licensing affect the value of an invention. It has further shown that the probability of cumulative innovation critically turns on how much value subsequent improvers may capture. This value left for subsequent improvers depends, in turn, on the breadth of the initial patent and the expected cost of producing the cumulative innovation. Importantly, the initial patentee has control over both parameters: She determines the breadth of the patent and she can substantially reduce the cost of follow-on innovation.

The implication of our analysis is that patentees, in cumulative innovation settings, may find it advantageous to narrow the scope of their patents and to publish some of their R&D results. This strategy facilitates cumulative innovation in two complementary ways. First, it increases the value that subsequent innovators can

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committing to a low—in fact a zero—licensing fee. It seems that regardless of the commitment to low licensing fees, however, the problem of inducing ex ante investments in sequential improvements is of a lesser magnitude in the open source context. See generally Benkler, supra note 45 (discussing the various motivations for individuals who engage in peer production).

[61] See, e.g., Cohen & Lemley, supra note 32, at 5 (noting the existence of "a strand of the theoretical literature which suggests that the optimal patent scope is broad"); Michael Dergosits & John Imperato, Patent Drafting in View of Recent Case Law on Claim Construction, 5 Intell. Prop. L. Bull. 1, 2 (2000) (arguing that patent lawyers should draft claims to achieve "the broadest available protection against infringement"); Peter H. Kang & Kristin A. Snyder, A Practitioner's Approach to Strategic Enforcement and Analysis of Business Method Patents in the Post-*State Street* Era, 40 IDEA 267, 283 (2000) ("Patent prosecutors drafting method patent claims should be careful to draft claims with as broad a scope as possible."); Thomas K. Landry, Constitutional Invention: A Patent Perspective, 25 Rutgers L.J. 67, 88 (1993) ("One task for the inventor's patent attorney is to gain allowance by the [Patent & Trademark Office] of the most broadly worded claims possible."). It has also been argued that strong intellectual property protection can facilitate socially desirable creation and dissemination of information. For an excellent discussion, see R. Polk Wagner, Information Wants to Be Free: Intellectual Property and the Mythologies of Control, 103 Colum. L. Rev. 995 (2003).

appropriate and reduces the cost of developing improvements. When patent protection is very broad, cumulative innovators may not be able to capture enough value to cover both R&D expenses and the licensing fee. This result is undesirable not only to the public at large, but also to the original patentee, who stands to lose potential licensing revenues. Publication of some research results allows the original patentee to redivide the inventive surplus between herself and cumulative innovators and thereby increase the incentive to produce cumulative innovation.

Second, the information disclosed in publications lowers R&D costs for cumulative innovators and can encourage them to pursue improvements to the original invention. Given that innovation is highly path dependent,[62] the provision of free research leads may attract cumulative innovators to improve on the patented inventions of the publishing firm.[63]

II. THE ORIGINAL INVENTOR'S STRATEGIC CHOICE: PUBLISH OR PATENT

In this Part, we develop the argument that the original inventor may often prefer unprotected publication to patent protection. Furthermore, the analysis identifies the precise conditions that determine the original inventor's choice of strategy: publish or patent. We begin, in Section A, with a simple binary example, where the original inventor can choose only between two possible patents—a broad or a narrow patent. In Section B, we extend the example to allow for a continuous choice of patent breadth. Finally, in Section C, we consider the case of multiple cumulative innovations. A mathematical appendix demonstrates the generality of the insights derived from our numeric example.

A. A Binary Example

An original inventor, A, makes a technological breakthrough. The breakthrough is valuable in itself, but the bulk of the potential value lies in the prospect of cumulative innovation based on A's discovery. In particular, assume that if A obtains a broad patent on

[62] Michael A. Carrier, Unraveling the Patent-Antitrust Paradox, 150 U. Pa. L. Rev. 761 (2002) (arguing that innovation is based on different paths in different industries).

[63] For a detailed discussion, see infra Part IV.

her new technology, she will enjoy a payoff of 400 from her original invention. Alternatively, *A* can choose to seek a narrow patent, covering only part of her discovery, and to publish part of the discovery without IP protection. Assume that the narrow patent will generate a lower payoff of 200 from the original invention.[64] Focusing only on the revenues that can be generated from the original discovery, *A* would prefer a broader patent; as noted above, however, most of the potential value lies in the prospect of cumulative innovation.

Therefore, *A* must consider the effects of her choice between a broad patent and a narrow patent with unprotected publication on the revenues that she expects to extract from cumulative innovation.[65] If cumulative inventions are expected to appear regardless of *A*'s strategic patent or publish choice, then again a broad patent is optimal for *A*. Cumulative inventions, however, do not simply appear. They are generally the product of significant ex ante investments by the cumulative inventor. And, as we elaborate below, *A*'s choice between a broader patent and unprotected publication will determine whether cumulative inventors will make these investments.

In fact, *A* faces a third alternative—to opt for a narrow patent without unprotected publication. While keeping portions of the original invention secret (and subject to the weaker protection provided by trade secret law) may be appealing in certain settings, this strategy is less likely to be optimal in the cumulative innova-

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[64] This is the case because a narrow patent allows for the development and marketing of closer substitutes to *A*'s product, thus reducing *A*'s monopoly power. See Paul Klemperer, How Broad Should the Scope of Patent Protection Be?, 21 RAND J. Econ. 113, 114 (1990) ("[T]he width of the patent is the distance from the preferred [patented] point to that point beyond which competitors are allowed to produce."); see also Richard Gilbert & Carl Shapiro, Optimal Patent Length and Breadth, 21 RAND J. Econ. 106 (1990) (stating that patent breadth is measured by the price that the patent holder can charge for the patented product); Shavell, supra note 6, at 7 ("Issues of the scope of protection are exemplified by whether a closely-related improvement on a patented invention will be considered infringing . . . .").

[65] We focus on cumulative innovation by other inventors—that is, not by *A*. The assumption is that the initial inventor will not have the ideas or the expertise to develop all possible cumulative innovations. See, e.g., Scotchmer, supra note 10, at 31–32 ("Since the first innovator might not have expertise in all applications, more second generation products are likely to arise if more researchers have incentive to consider them . . . . [C]reativity is largely serendipitous. Not every R&D firm sees the same opportunities for new products.").

tion context. When the lion's share of the value depends on cumulative innovation, it is imperative—both socially and from the perspective of the original inventor—that information regarding the original invention be made public. Otherwise, the road to cumulative innovation based on the original invention will be blocked. Therefore, in this example we assume that *B* would not have come up with the idea for the cumulative invention if the information regarding *A*'s discovery was not made public. Namely, if *A* had chosen to keep part of her discovery secret, rather than to patent it (with the ensuing publication) or to publish it without patent protection, then there would be no cumulative innovation to *A*'s detriment. We thus focus on *A*'s choice between a broader patent and a narrower patent coupled with unprotected publication.

Assume that a cumulative inventor, *B*, considers whether to invest 350 in the development of a cumulative invention. In making this decision, *B* tries to assess whether he will be able to recoup his initial investment. In particular, *B* knows that while he may be able to extract some value from his investment without *A*'s approval, the bulk of the value created by the cumulative invention lies in the combination of *B*'s development with *A*'s initial discovery. To realize this value, *B* will need to negotiate a license with *A*.[66] For simplicity, we assume that *B*'s cumulative invention is valueless on its own, but can produce revenues of 1000 when combined with *A*'s original discovery.[67]

A's strategic choice between patenting or publishing her original discovery directly affects *B*'s considerations. *A*'s strategy determines the parties' relative positions in the licensing negotiations,

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[66] Alternatively, one could assume that *B*'s invention may or may not infringe upon *A*'s original patent (so that before developing his idea *B* knows only the probability of infringement), where the probability of infringement is increasing in the breadth of *A*'s patent. See, e.g., Gallini & Scotchmer, supra note 10, at 67 ("Contracting is especially relevant to the question of breadth, which determines the likelihood that a follow-on innovation will infringe a prior patent."); Scotchmer, supra note 10, at 33–34, 38 ("The breadth of the prior patent determines the probability that the second generation product will infringe."). A third possible assumption is that with an investment of 350, *B* will necessarily infringe upon *A*'s patent, but that with an additional investment *B* could invent around *A*'s patent. Bessen, supra note 6, at 5 (stating that the sequential innovator "might undertake additional development efforts to 'invent around' the patent").

[67] Namely, *B*'s investment in developing the cumulative innovation is a relationship-specific investment.

and hence the share of the surplus that *B* expects to receive. Only if this share exceeds the ex ante investment of 350 will *B* consider developing the cumulative invention.[68]

In particular, as noted above, *A*'s strategy determines the value that *A* can obtain from her original discovery without *B*'s cumulative invention. This "outside option" determines the outcome of the bargaining between *A* and *B* over the division of the revenues from the cumulative invention.[69] Let us consider the bargaining outcome under *A*'s two possible strategies.

If *A* opts for a broad patent, then her outside option equals 400. In other words, *A* will not accept any price below 400 for the license.[70] From *B*'s perspective, at the ex post bargaining stage, *B*'s

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[68] The effect of the breadth of the original patent on the parties' threat points in the license negotiations has been previously recognized. See, e.g., Green & Scotchmer, supra note 7, at 27 ("Our main objective has been to study patent policy, and to show the important role of patent breadth in setting threat points for negotiating licensing agreements between sequential innovators."); Scotchmer, supra note 10, at 32 ("[A] key role of patent protection is that it sets bargaining positions for the prior agreements and licenses that will form, and therefore determines the division of profit in these contracts."); see also Chang, supra note 10, at 43 ("The court's decisions [regarding antitrust regulation and patent scope] would set the threat point for [the bargaining over a licensing agreement]."). The parties' relative bargaining positions are affected not only by the breadth of the original patent, but also by the applicable enforcement regime. See Mark Schankerman & Suzanne Scotchmer, Damages and Injunctions in Protecting Intellectual Property, 32 RAND J. Econ. 199 (2001).

[69] *A*'s strategy can also affect the value of *B*'s outside option. This extension is analyzed in the Appendix, infra.

[70] It is assumed that the outside option, on the one hand, and the combination of the original discovery and the cumulative invention, on the other hand, are mutually exclusive. For instance, this will be the case if the combination of the two inventions will produce a superior product that would trump any attempt by *A* to market a product based only on her original discovery. More generally, the profits that an original inventor can make using only her original discovery can be divided into two categories. The first category of profits will dissipate following the introduction of a new product based on the combination of the original and cumulative inventions. The second category of profits will not be affected by the introduction of the new product. In this more general formulation, *A*'s outside option is determined by the first category—namely by the difference between *A*'s profit absent the cumulative innovation and *A*'s profit (from her original product) with the cumulative innovation. This formulation also covers the case where *A* invents a basic technology—such as the LCD screen—and *B* (or several *B*s) may develop application(s) for this basic technology—such as a digital watch or a digital phone. In this case, *A*'s outside option is defined as follows: If *A* and *B* fail to reach a licensing agreement, *A* may try to invent around *B*'s patent or to develop an alternative application, which would be inferior to *B*'s application. *A* forgoes these outside options, or reduces their value, by licensing her technology to *B*, since if *B* can market his application, *B* will have gained control of the relevant mar-

investment is already sunk. Hence, since *B* has no outside option, *B* will be willing to pay any price, up to the full value of 1000, for the license. Within this bargaining range—400 to 1000—the price of the license will be determined by the parties' relative bargaining power, as determined by their relative size, experience, and patience.[71] Assume that *A* and *B* have equal bargaining power,[72] such that within the 400 to 1000 price range the actual price will be set at 700. This price leaves *B* with a revenue of 1000 – 700 = 300, which does not cover *B*'s initial investment in developing the cumulative invention.[73]

Now consider the case where *A* chooses a narrow patent, accompanied by unprotected publication. With this narrow patent *A*'s outside option is only worth 200. Consequently, the minimal price that *A* will accept is now 200, rather than 400, and the bargaining range becomes 200 to 1000. Assuming equal bargaining power, the price that *B* will pay for the license is now only 600,

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ket by the time *A* invents around him, or *B*'s product will drive out *A*'s inferior application.

[71] On the determinants of bargaining power, specifically patience, or, in economic terms, a party's discount rate, see Ariel Rubinstein, Perfect Equilibrium in a Bargaining Model, 50 Econometrica 97 (1982); see also Drew Fudenberg & Jean Tirole, Game Theory 113–17 (1991) (explaining that because bargainers only have a finite amount of time to bargain, the party with more time and better outside options has the advantage); Martin J. Osborne & Ariel Rubinstein, A Course in Game Theory 126–27 (1994) (demonstrating how an impatient bargainer is disadvantaged because the other party can force an agreement now instead of a better agreement later).

[72] This assumption is made only for clarity of exposition. See also Chang, supra note 10, at 43 (similarly assuming that the parties will evenly split the bargaining surplus when contracting ex ante); Green & Scotchmer, supra note 7, at 24 (same). We relax this assumption in the formal analysis, which is provided in the Appendix.

[73] Arti Rai discusses an example of hold-up by an initial inventor:

> Holdup rights are a particular problem if the original patent contributes very little value relative to the improvement—as is likely to be the case with respect to the EST [patented gene fragment information] in question .... In that case, the holder of the original EST patent may be able to extract value significantly greater than its actual contribution .... Consider a situation where the original EST patent has a value of $100,000 (an arbitrary figure). The full gene, which is also patented, is worth $900,000 (also an arbitrary figure). Even if the EST patent holder demands "only" an equal allocation of the improvement's value, the improver is limited to $450,000 of the total value of the improvement.

Rai, Regulating, supra note 6, at 128; see also Rai, Fostering, supra note 6, at 835 (explaining that vertical integration likely would not avoid the transaction cost of licensing to other innovators because the vertically integrated firm would not produce the desired cumulative innovation).

leaving B with a revenue of 1000 – 600 = 400, which is sufficient to cover B's ex ante investment.[74]

Comparing the two cases, we find that with the broad patent there will be no cumulative innovation and A will be forced to make do with her outside option, valued at 400. By publishing rather than patenting, A commits a sufficiently large share of the surplus to B, thus inducing the development of the cumulative invention. Importantly, A enjoys a substantial chunk of the enhanced surplus created by the cumulative innovation. Specifically, A's 600 licensing fee under the publish strategy surpasses the 400 payoff she would receive under the patent strategy.[75]

B. A Continuous Choice of Patent Breadth

To extend the example studied in section A, we now relax the assumption of binary patent breadth and allow the original inventor, A, to choose from a continuum of possible patent breadths. In particular, we assume that A controls the breadth of her initial patent, so that it can generate a payoff, r_A, between 200 (the narrow-

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[74] This analysis borrows from the Property Rights theory in economics. See, e.g., Oliver Hart, Firms, Contracts, and Financial Structure 29–55 (1995). In this theory, assets or entitlements are used as bargaining chips, thus affecting the outcome at the ex post bargaining stage. In our context, A strategically chooses the extent of her entitlement—by opting for a broader or narrower patent—thus affecting the value of her outside option and, consequently, the bargaining outcome. See also Sanford Grossman & Oliver Hart, The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration, 94 J. Pol. Econ. 691 (1986) (developing the Property Rights theory and applying it to the study of integration between firms); Oliver Hart & John Moore, Property Rights and the Nature of the Firm, 98 J. Pol. Econ. 1119 (1990) (same).

[75] Our analysis focuses on ex post licensing, assuming that ex ante contracting is difficult (namely, that the initial and subsequent inventors cannot write a complete ex ante contract). Such contractual incompleteness may arise when the identity of the subsequent innovator is unknown to the initial inventor, or when imperfect verification prevents the two parties from writing a complete contract. See generally Oliver Hart & Bengt Holmström, The Theory of Contracts, *in* Advances in Economic Theory: Fifth World Congress 71, 128–41 (Truman F. Bewley ed., 1987) (presenting the incomplete contracts theory). The initial inventor also may prefer a narrower patent when taking an ex ante contracting, rather than an ex post licensing, perspective. See Green & Scotchmer, supra note 7, at 31. In the same spirit, Mark Schankerman and Suzanne Scotchmer, supra note 68, at 200, find that the initial inventor may prefer lower damages in case of infringement by the cumulative innovator, when higher damages will generate a credible threat by the cumulative innovator not to develop the product and thus enhance the bargaining power of the cumulative innovator.

est possible patent) and 400 (the broadest possible patent) as a stand-alone invention (that is, without any cumulative innovation).

We further assume that ex ante, when A chooses the breadth of her patent, she does not know what investment would be required to develop the cumulative innovation. Rather, A only knows the distribution from which the investment in cumulative innovation will be drawn.[76] Specifically, assume that the investment required to develop the cumulative innovation, c, is uniformly distributed between 300 and 400. After A chooses the breadth of her patent, the cost, c, is realized, and B decides whether to invest in developing the cumulative innovation. As before, we assume that B's cumulative invention is valueless on its own, but can produce revenues of 1000 when combined with A's original discovery.

As shown in Section A, if B decides to invest in the cumulative invention, he will pay $\frac{1}{2}\cdot[r_A+1000]=500+\frac{1}{2}\cdot r_A$ for a license, and thus end up with a payoff of $500-\frac{1}{2}\cdot r_A-c$. Consequently, B will invest in a cumulative invention if, and only if, $500-\frac{1}{2}\cdot r_A-c>0$, that is, if, and only if, $c<500-\frac{1}{2}\cdot r_A$.

Therefore, ex ante, A can calculate the probabilistic relationship between the chosen patent breadth and the likelihood of cumulative innovation. Specifically, given a patent breadth r_A, the probability that a cumulative innovation will be developed equals:

$$q=\Pr\left[c<500-\tfrac{1}{2}\cdot r_A\right]=\left(500-\tfrac{1}{2}\cdot r_A-300\right)/100=\left(200-\tfrac{1}{2}\cdot r_A\right)/100.$$

The relationship between the breadth of A's original patent, r_A, and the probability that a cumulative innovation will be developed, q, is presented graphically in Figure 1.

[76] In fact, the main result of the analysis—that A may prefer a narrower patent coupled with unprotected publication—holds even if A does not have perfect knowledge of the distribution from which the investment in cumulative innovation will be drawn.

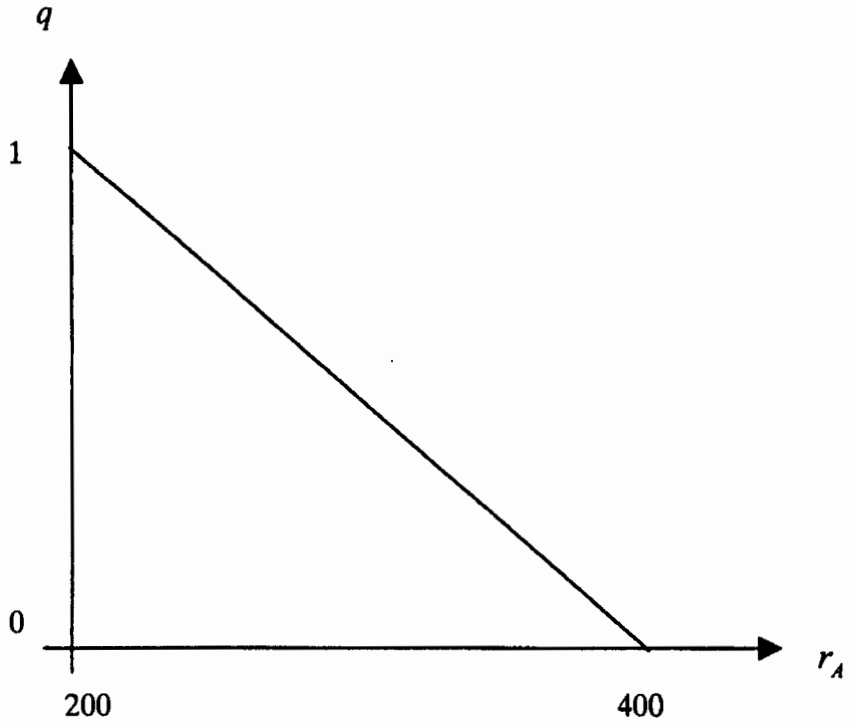

Figure 1: Patent breadth and the likelihood of cumulative innovation

As illustrated in Figure 1, the likelihood of cumulative innovation decreases as the breadth of the patent on the original invention increases.

The reduced likelihood of cumulative innovation, however, does not necessarily entail that A would optimally choose a narrow patent. Hence, we now proceed to derive A's overall profits as a function of the breadth of the patent on A's original invention. From Section A, we know that A's profits from licensing fees equal $500+\frac{1}{2}\cdot r_A$ if a cumulative invention exists. If B decides not to invest in the cumulative invention, however, A must settle for her outside option, r_A. Therefore, A's ex ante expected profit equals:

$$\pi = q(r_A)\cdot(500+\tfrac{1}{2}\cdot r_A)+(1-q(r_A))\cdot r_A .$$

Given the chosen patent breadth, r_A, with probability $q(r_A)$ the cumulative innovation will be developed, and A will enjoy the licensing fee $500+\frac{1}{2}\cdot r_A$. With probability $1-q(r_A)$, B will decide not to invest in the cumulative innovation, leaving A with the profits generated by her initial invention as a stand-alone product, r_A.

Since $500+\frac{1}{2}\cdot r_A > r_A$ (or, equivalently, $r_A < 1000$), A will always prefer to increase the probability that B will invest in a cumulative innovation by opting for a narrower patent, that is, by choosing a smaller r_A.[77] As a result, A will opt for the narrowest possible patent, $r_A = 200$.[78]

C. Multiple Cumulative Innovations

For expositional purposes, the preceding analysis assumed a single cumulative innovator. Yet, often a single initial invention can spur multiple sequential developments. The existence of such a situation may significantly enhance the appeal of the publishing strategy.

To illustrate this, let us return to the basic model from Section A. Rather than a single cumulative innovator, however, assume that there are n potential sequential innovators, *B1*, *B2*, . . ., *Bn*. For instance, if A has an initial patent on the LCD screen, *B1* can create a digital watch, *B2* can create a digital phone, *B3* can create a digital thermometer, *B4* can create a digital home security alarm, etc. Also, assume that all of the potential improvers face the same cost structure and the same potential revenues, as specified in Section A.

Under these assumptions, the advantage—from A's perspective—of opting for a narrow patent, coupled with unprotected publication, is significantly higher than the advantage described in the basic Section A model. Specifically, as in Section A, if the initial inventor chooses a broad patent, none of the n potential improvements or applications will be undertaken, leaving A with a profit of

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[77] This effect dominates the countervailing effect that a smaller r_A reduces A's profits both when a cumulative invention exists and when it does not. Formally, $d\pi/dr_A = q'(r_A)\cdot(500+\frac{1}{2}\cdot r_A - r_A)+\frac{1}{2}\cdot q(r_A)+(1-q(r_A))$, or $d\pi/dr_A = q'(r_A)\cdot(500-\frac{1}{2}\cdot r_A)+(1-\frac{1}{2}\cdot q(r_A))$. Substituting, we obtain: $d\pi/dr_A = -1/200\cdot(500-\frac{1}{2}\cdot r_A)+1-(200-\frac{1}{2}\cdot r_A)/200 = (r_A-500)/200$. Since $r_A < 500$, this derivative is always negative, implying that A will prefer the narrowest patent, that is, $r_A = 200$.

[78] While A clearly has an incentive to limit the breadth of the patent on her initial invention, the result that A will opt for the *narrowest* possible patent is not generally true. For instance, if the cost of developing the cumulative innovation, c, is drawn from a Normal distribution, rather than from a Uniform distribution, an intermediate patent breadth may be optimal for A.

400. If the initial inventor opts for a narrow patent, however, all n sequential innovations will be developed, each yielding 600 in licensing fees. Hence, A obtains a profit of $n \times 600$.

III. NORMATIVE IMPLICATIONS AND POLICY RECOMMENDATIONS

The preceding analysis not only furthers our positive understanding of the strategic choice made by initial inventors regarding patent breadth and unprotected publication, but it also entails important normative ramifications. These normative ramifications and their policy implications are discussed below.

A. Social Goals and Private Objectives

The legal and economic literature teaches that intellectual property protection, while often necessary for creating incentives for innovation, also generates substantial efficiency costs through the inevitable divergence between social goals and the private objectives of the IP holder. On the static dimension, the social cost equals the deadweight loss from the monopoly power conferred upon the patent holder. On the dynamic level, granting a patent on an initial invention might curtail sequential improvements. Finally, in the cumulative innovation context, the patent system may fail to induce investment in a socially desirable initial invention, since the patent holder generally cannot appropriate the entire surplus created by the stream of products that builds on her initial invention.[79] The publishing strategy serves to align the private interests of the initial inventors with social objectives on these three dimensions.

1. Static Considerations—Limiting the Monopoly

Starting with the static considerations, the appeal of narrow patents to original innovators reduces the tension between IP protection and welfare-enhancing competition. A main cost of the patent system is the creation of a monopoly.[80] While, ex ante, IP protec-

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[79] A similar problem exists in the static context as well, absent cumulative innovation. Since the monopolist patent holder generally will not be able to appropriate the entire consumer surplus, some socially valuable products will not be developed. See, e.g., Shavell, supra note 6, at 4.

[80] See, e.g., Landes and Posner, supra note 8 (manuscript at 383) (pointing out the "danger that the inventor will be enabled to charge a higher price than he needs to

tion may be necessary to induce the development of a certain product or technology, ex post this product or technology ends up in the hands of a monopolist, with the ensuing inefficiency of a monopoly. In particular, the monopolist will charge a higher price and produce a smaller quantity, as compared to the social optimum.[81]

The costs of IP protection increase in relation to the strength of the patent holder's monopoly—that is, to the breadth of the patent. As a result, critics often call for limiting the breadth of patent protection. Our analysis suggests that legal reform imposing narrow patents may be unnecessary. At least in the cumulative innovation context, the initial patent holder has a private incentive *not* to request a broad patent.

As we have shown, in order to encourage cumulative innovation that will increase her profits, the initial inventor often will prefer a narrow patent. While aimed at providing dynamic private profits, the narrow patent generates static social gains. The narrow patent allows for the development of partial substitutes for products based on the original discovery, without fear of infringement. The enhanced competition generated by these substitutes can be expected to increase consumer surplus and enhance social welfare.[82]

2. Dynamic Considerations I—Spurring Cumulative Innovation

Conventional wisdom suggests that initial inventors will opt for broad patents, thus hindering technological progress via cumula-

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recover the fixed costs of his invention, thereby restricting access to the invention more than is necessary"); Shavell, supra note 6, at 4 ("When parties possess property rights in information, they will sell goods embodying the information at prices exceeding the cost of production, so that the level of purchases of the goods will be less than is socially desirable.").

[81] See, e.g., Andreu Mas-Colell et al., Microeconomic Theory 384–87 (1995) (demonstrating that a monopolist will set an inefficiently high price and produce an inefficiently low quantity).

[82] Put differently, a narrow patent limits the monopoly power of the original inventor, and thus reduces the deadweight loss associated with the patent monopoly. Once the cumulative invention is developed and combined with the original discovery, however, a more powerful monopoly might result. Still, the increased surplus created by cumulative innovation will generally outweigh the deadweight loss generated by this monopoly. See, e.g., Scotchmer, supra note 10. The presumption in Scotchmer's seminal article, as well as in the growing literature on cumulative innovation, is that it is socially desirable to encourage technological progress.

tive innovation.[83] Our results regarding the alignment of private goals and social objectives are more optimistic. We have shown that initial inventors, in order to maximize their own profits, often will opt for narrower patents, coupled with unprotected publication. This strategy provides a commitment not to extract excessive rents, in the form of high license fees, from sequential innovators. By adopting such a strategy, the initial inventor promotes cumulative innovation.

When the bulk of the revenues from the initial invention will likely follow from licensing the technology to sequential innovators, the initial inventor has a powerful incentive to encourage cumulative innovation by opting for a narrower patent. The goal of promoting cumulative innovation is not necessarily at odds with the private interests of initial inventors.[84]

At the policy level, this finding cautions against proposals to limit patent breadth in the name of cumulative innovation. Imposing such limits is unnecessary when the initial innovator has a private interest in refraining from requesting an excessively broad patent. Moreover, in some cases a broader patent may be necessary for the creation of the initial invention. In these cases, imposing a legal limit on patent breadth might discourage investment in the initial invention, which clearly precludes cumulative innovation as well.[85]

The increased willingness to publish research findings will enhance dynamic efficiency on yet another dimension. The pro-publication trend guarantees that some technological and scientific information stays available to all. Thus, the recent spate of publications may serve as a counterforce to the much-lamented "anti-commons" problem, which stems from the over-appropriation of

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[83] See supra note 10.

[84] On the contrary, the initial inventor may even have an incentive to encourage cumulative innovation beyond the socially optimal level. Importantly, when the costs of cumulative innovation are taken into consideration, investment in cumulative innovation might not be socially desirable. Specifically, private incentives may lead to socially excessive investment in cumulative innovation. See, e.g., Kitch, supra note 10, at 275–80 (warning of the danger of excessive investment). Also, by increasing the value of the initial invention, the narrow patent with publication strategy might exacerbate the patent race problem and the extent of duplicate efforts to develop the initial patent.

[85] See also infra Section III.A.3.

scientific know-how.[86] Furthermore, by providing a focal point for future innovation, unprotected publications can facilitate the creation of technological standards.

3. Dynamic Considerations II—Encouraging the Initial Inventor

We have thus far focused on one aspect of dynamic efficiency—the promotion of cumulative innovation, given the existence of the original invention. In the cumulative innovation context, however, the challenge is not only to induce sequential innovation, but also to ensure the development of the original invention. After all, without the initial invention there will be no cumulative innovation.

The problem is that most of the surplus from a basic discovery often lies in the development of cumulative innovation.[87] Hence, if the initial inventor cannot extract enough surplus from the sequential innovators, she might not develop the basic invention.[88] As demonstrated above, the publishing strategy increases the return from investment in the initial invention and thus raises the probability that the initial discovery will be made.

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

[87] "This is particularly evident in the case of a research tool for which all the social value resides in the innovations it facilitates." Gallini & Scotchmer, supra note 10, at 65.

[88] See Green & Scotchmer, supra note 7:

> [W]hen innovation occurs in two stages, the first innovator may have insufficient incentive to invest .... [T]he social value of an early innovation includes the net social value of the applications it facilitates. If the first innovator does not collect that value as profit, he might not invest even if the combined profit of the innovations exceeds the combined costs.

Id. at 20; see also Scotchmer, supra note 10, at 30 ("[P]roper incentives to find fundamental technologies may require that the first patent holder earn profit from the second generation products that follow."); Gallini & Scotchmer, supra note 10, at 65 (arguing that efficient investment by the initial inventor requires that this inventor recoup the gains from the follow-on inventions); Shavell, supra note 6, at 8 (same). More generally, if one considers the optimal level of investment by the initial inventor, this level cannot be achieved unless the initial inventor captures the full social benefits from her invention, so that she can equate marginal benefit to marginal cost. Similarly, to induce optimal investment by the cumulative innovator, the cumulative innovator should retain the full social benefit from the cumulative invention. The tension between these two requirements is obvious. See Gallini & Scotchmer, supra note 10, at 65–66; Scotchmer, supra note 10, at 30.

B. A Modest (Yet Crucial) Reform in Patent Law

The preceding analysis has demonstrated both the private and the social value inherent in the publishing strategy. The ability of the initial inventor to commit a higher share of the surplus to sequential innovators is key in creating this added value. The credibility of this commitment, in turn, depends on the relative timing of the publication and (narrow) patenting elements of the publishing strategy.

Under current law, inventors are allowed to publish research findings and later seek patent protection for them, as long as they file for a patent within one year of the date of publication.[89] Moreover, patent applications are published eighteen months after the filing date.[90] Therefore, theoretically, an initial patent holder may publish information on January 1, 2004 and file for a patent on December 31, 2004, and this filing will not be made public until June 30, 2006. Only if the sequential innovator makes his investment decision after June 30, 2006—two and one-half years after publication by the initial inventor—can he be certain that the initial inventor will not stick to the narrow patent, leaving the previously published information in the public domain.[91]

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[89] 35 U.S.C. § 102(b) (2000).

[90] Furthermore, the patent applicant can prevent publication of the patent application even after the eighteen-month period. See id. § 122(b)(2)(B)(i) ("If an applicant makes a request upon filing, certifying that the invention disclosed in the application has not and will not be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication of applications 18 months after filing, the application shall not be published as provided in paragraph (1).").

[91] In theory, a potential cumulative innovator can approach the initial inventor and request: (1) in the first year following the publication, a formal contractual obligation that the initial inventor will not file a patent application with respect to the published information; or (2) subsequent to the first year following the publication, a signed affidavit that the initial inventor has not already filed such a patent application. This strategy, however, suffers from significant practical drawbacks. First, it may involve substantial transaction costs, especially when there are numerous potential cumulative innovators. These transaction costs may prevent the initial inventor from entering into the proposed contractual obligations. Second, the mere act of approaching the initial inventor may be costly to the cumulative innovator. A request for a formal obligation to refrain from patenting the published information may reveal information to the initial inventor. Specifically, the initial inventor may decide to invest further in exploring the potential applications of the published information. Potentially, this could lead the initial inventor to file a patent application, if the one-year post-publication period has not ended, to the detriment of the cumulative innovator.

Opportunities for cumulative innovation can present themselves before June 30, 2006, however. In many industries, two and one-half years is a very long time. One of the central advantages of the publishing strategy is that it spurs rapid technological progress. Arguably, the initial patent holder, in her January 1, 2004 publication, can promise not to patent the published information; but it may be quite difficult to guarantee the credibility of such a promise.

The ability of inventors to patent previously published results dilutes the signal sent by publishing and is likely to ward off improvers. In the two and one-half year period between the first publication by the initial inventor and the final date for possible publication of an application for a broad patent, aspiring improvers are likely to be justifiably reluctant to rely on publications.

Thus, to realize the full beneficial effect of publications, and to prevent abuse, the law should allow inventors to commit credibly not to patent research results that they first choose to publish. This socially desirable result can be implemented readily by affecting a relatively minor reform in patent law: Allow a patent holder to tie her own hands by undertaking an explicit commitment not to seek patent protection for published information. Practically, given such a commitment, the PTO would dismiss a patent application covering the published information. Importantly, this proposal *enables* inventors to commit to refrain from patenting, but it does not *require* such a commitment. It both preserves the ability of inventors who wish to secure patent protection to publish their research results up to a year before filing and establishes a way for inventors who wish to forego patent protection altogether to credibly signal this preference to follow-on inventors. By effecting a separating equilibrium that permits both inventor types to satisfy their respective preference, our proposal ensures that there would be no decrease in the number of disclosures. Hence, our proposal cannot be criticized for deterring inventors who plan to patent their discoveries from publishing early.[92]

[92] Put differently, our proposal induces an efficient separating equilibrium, where inventors engage in self-sorting: Some choose a broad patent, possibly preceded by publication, and some commit to a narrow patent through unprotected publication. We are grateful to Robert Merges for helping us to refine the proposed reform.

IV. POTENTIAL OBJECTIONS

In this Part, we respond to two potential objections to our analysis. First, we consider the argument that narrow patents without publication provide an equally good mechanism for enticing cumulative innovation. Second, we discuss the possibility that the recent spate of publications may be better explained by the relatively high cost of patenting. We show that neither objection significantly undermines our analysis.

A. Narrow Patents without Publication

One possible objection to our analysis is that narrow patents without publication provide initial patentees with a superior mechanism for eliciting cumulative innovation. The appeal of this mechanism lies in the fact that it allows the patentee to leave enough value for cumulative innovators and, at the same time, retain a head-start vis-à-vis other firms in the race for subsequent improvements. In other words, this strategy enables the original patentee to enjoy the best of both worlds: to attract cumulative innovation with the ensuing licensing fees without giving up any valuable information.

A closer inspection reveals that this advantage is illusory. Absent publication, initial patentees will not be able to lure follow-on improvers. The reason for this is two-fold. First, the signal generated by narrowing the scope of the patent is likely to get lost due to asymmetric information. Without publication, cumulative inventors cannot know how much the initial patentee could claim. Consequently, they will not realize that she attempted to transfer some value from herself to them. As we explained, publication is a commitment device. When a patentee chooses not to publish, and thereby keeps all of her options open, she effectively refuses to commit. Given that the initial patentee has a head start on other improvers, it is only natural that cumulative innovators will be reluctant to compete with the patentee for subsequent improvements.[93]

[93] It is important to realize that new technology has dramatically improved the ability of cumulative innovators to screen for suitable inventions. Indeed, the art of searching has improved so much that a new term, "patinformatics," has been coined

Second, by not publishing, the initial patentee suppresses information from potential improvers and thus increases the cost of producing cumulative innovation. In addition to being a commitment device, publications serve an instructive function. They provide free information to cumulative innovators, as well as useful guidance for future research. Accordingly, publications lower the cost of cumulative R&D and increase the likelihood of success. Narrow patents, on their own, achieve neither effect. Indeed, in this regard, narrow patents without publication may be inferior even to broad patents accompanied by detailed publications.

B. The Cost of Patenting

A different challenge to our analysis is predicated on the cost of patenting. The argument proceeds as follows. The costs of securing and defending a patent are nontrivial.[94] Empirical studies suggest that in some cases, the cost of obtaining patent protection may be as high as $50,000. Therefore, one may argue that it does not make economic sense to pursue patent protection for relatively modest technological advancements. Failing to patent, however, subjects one to the risk that a competitor will patent the same research findings, and thereafter exclude the original discoverer. Publication reduces that risk. Section 102(b) of the Patent Act withholds protection from inventions that were "patented or described in a printed publication in this or a foreign country . . . more than one year prior to the date of the application for patent in the United States . . . ."[95] By virtue of this Section, publication may be used as a defensive mechanism that restricts the ability of rival firms to ap-

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to describe it. See Anthony J. Trippe, Patinformatics: Identifying Haystacks From Space, Searcher, Oct. 2002, at 28.

[94] See, e.g., Wayne M. Kennard, Software Patents and the Internet, 610 Prac. L. Inst. 311, 325–26 (2000) (placing the average cost of obtaining a software patent between $20,000 and $50,000); Mark A. Lemley, Reconceiving Patents in the Age of Venture Capital, 4 J. Small & Emerging Bus. L. 137, 138 n.3 (2000) (estimating that the average cost of prosecuting a patent is $25,000); Vincent P. Tassinari, Patenting Gaming Methods for Internet Use: A Managerial Imperative, 8 Nev. Law., June 2000, at 10, 11 (reporting that the cost of obtaining a patent may range between $6400 and $30,300).

[95] 35 U.S.C. § 102(b) (2000).

propriate certain information the publishing firm discovered first but elected not to patent.[96]

While we do not dispute that cost concerns may lead firms to publish defensively, we contend that cost-based arguments cannot completely explain the recent increase in the volume of publications. Nor can they explain the manner by which firms publish. First, many of the publishing firms employ in-house patent attorneys, a factor that dramatically lowers the cost of obtaining patents. For such firms, the marginal cost of obtaining a patent is represented by the fees charged by the PTO—$740 to file an application and $1280 to issue an approved patent application.[97] Given that a patent may yield millions of dollars in licensing fees over its life, patenting—not publishing—seems to be the profit-maximizing strategy, even if the ex ante probability of licensing is relatively low.[98]

A second problem with the cost-based story is that it is internally inconsistent. Recall that under Section 102(b) of the Patent Act, any publication in the United States or abroad may bar a patent from being issued to a competitor.[99] Construing the provision extremely broadly, the Federal Circuit held in *In re Hall*[100] that a doctoral dissertation that had been deposited and indexed in a German library was sufficiently accessible to constitute a statutory bar. In light of this case, one would expect publishing firms to publish discoveries in obscure places, where competitors are unlikely to find them. Concealing the publication enables the publisher to put the information in the public domain formally, without making it

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[96] For discussion of defensive, or preemptive, publication, see Lichtman et al., supra note 18; Parchomovsky, supra note 18; cf. Eisenberg, supra note 18 (arguing that the law protects leading firms from strategic preemptory publishing behavior by lagging firms).

[97] See PTO Fees and Payment of Money, 37 C.F.R. §§ 1.16(a), 1.18(a) (2002). For a detailed discussion of the aggregate cost of applying for patents, see Thomas, supra note 19, at 345.

[98] See Mark A. Lemley, Rational Ignorance at the Patent Office, 95 Nw. U. L. Rev. 1495, 1507 (2001) (estimating that "a relatively small percentage of the 150,000 or so patents issued each year are actually licensed to third parties in exchange for royalties").

[99] 35 U.S.C. § 102(b) (2000).

[100] 781 F.2d 897 (Fed. Cir. 1986).

accessible to competitors.[101] From a cost-based perspective, such strategic publication surpasses regular publication since it induces rival firms to continue to expend valuable resources on R&D on the false belief that they can patent the results. In other words, this publication strategy provides the publisher with an effective mechanism for raising rivals' costs.

Yet, publishing firms do not attempt to conceal their publications. On the contrary, they consciously publish in specially designated journals and websites that are readily accessible to competitors. This fact suggests that publishing firms are not solely motivated by defensive motifs. Rather, they have a complementary motivation of encouraging cumulative innovation.

CONCLUSION

This Essay has laid down a new paradigm of technological innovation. In the new age of cumulative R&D, progress does not hinge entirely, or even to a large extent, on exclusionary property rights. Rather, inclusion—through unprotected publication—emerges as the optimal strategy. Such inclusion fosters sequential improvements, which hold the key to a never-ending stream of innovation and revenue. By giving away secrets, the initial inventor plants the seeds of cumulative innovation. By opting for narrower IP protection, she commits a sufficiently large share of the ex post surplus to sequential improvers, ensuring the profitability of follow-on R&D investments and the viability of a continuous chain of technological improvements. Weaker property rights lead to greater licensing revenues. Less becomes more. In this new paradigm of innovation, free information is in the interest of the inventor. Private and social objectives converge.

APPENDIX

The Appendix formalizes and extends the analysis presented in Section II.

Consider the following sequence of events. At T=0, *A*, the initial inventor, makes her initial discovery, encompassing the informa-

[101] See Daniel Levi-Mazloum & Thomas von Ungern-Sternberg, To Patent or to Publish, 2 Small Bus. Econ. 191 (1990) (discussing the implications of this possibility).

tion set I. Next, at T=1, A chooses the breadth of the patent protection that she will claim on her discovery—that is, A chooses the protected subset $I_{Pat} \subseteq I$. We assume that A publishes (without any IP protection) any information that she does not include in the patent application. Let $I_{Pub} \subseteq I$ denote the subset of unprotected published information. By definition, $I_{Pat} \cap I_{Pub} = \phi$ and $I = I_{Pat} \cup I_{Pub}$.

At T=2, a potential cumulative innovator, B, considers whether to undertake an investment, c, that would generate a patentable cumulative invention. Even if B decides to invest c and obtains a patent on the cumulative innovation, B still cannot market his invention. Since the cumulative investment builds on A's original patent, B must obtain a license from A. If B developed a cumulative invention at T=2, then B approaches A at T=3, and the two parties negotiate a license agreement.

The price that B will have to pay for the license depends on the value of the cumulative invention, on the parties' outside options, and on their relative bargaining power. Assume that the value of the cumulative invention, together with the original invention, is R. Also, assume that A's outside option is a function of the breadth of her patent, $r_A(I_{Pat})$, where r_A is increasing in I_{Pat}. B's outside option is also a function of the breadth of A's patent, $r_B(I_{Pat})$, where r_B is *decreasing* in I_{Pat}. Alternatively, B's outside option is a function of I_{Pub}, $r_B(I_{Pub})$, where r_B is *increasing* in I_{Pub}.[102] Under these assumptions, B will pay $p = \theta \cdot r_A(I_{Pat}) + (1-\theta) \cdot (R - r_B(I_{Pat}))$ for the license, where $\theta \in [0,1]$ represents B's bargaining power, and $1-\theta$ represents A's bargaining power.[103] This leaves A with a payoff of:

$$\Pi_A = p = r_A(I_{Pat}) + (1-\theta) \cdot [R - (r_A(I_{Pat}) + r_B(I_{Pat}))].$$

And, B is left with a payoff of:

$$\Pi_B = R - p = r_B(I_{Pat}) + \theta \cdot [R - (r_A(I_{Pat}) + r_B(I_{Pat}))].$$

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[102] The analysis can readily be extended to allow for the investment c to depend on I_{Pat}.

[103] When B has all the bargaining power, that is, $\theta = 1$, he will only pay A the value of her outside option, r_A. When A has all the bargaining power, that is, $\theta = 0$, she will extract from B a price of $R - r_B$, leaving B with only the value of B's outside option, r_B.

We assume that the combined value of the original and cumulative innovations is sufficiently large, so that $R > r_A(I_{Pat}) + r_B(I_{Pat})$ for any I_{Pat}.[104]

We can now state the following preliminary result:

Lemma: By patenting less and publishing more, A reduces p and increases Π_B.

This result captures two effects:

By patenting less and publishing more, A improves B's outside option, thus reducing p and increasing Π_B.[105]

By patenting less and publishing more, A reduces the value of her own outside option, thus reducing p and increasing Π_B.

Based on the preceding lemma, we can state the following proposition:

Proposition: When $c \in (\Pi_B(I_{Pat} = I), \Pi_B(I_{Pat} = \phi))$, A's optimal strategy may include some publishing of non-patented information. A would be more likely to publish, rather than patent, when (i) R is larger and (ii) θ is smaller.

Proof: With no publishing, that is, with $I_{Pat} = I$, $\Pi_B < c$ and thus B will not invest in the cumulative invention, leaving A with $r_A(I_{Pat} = I)$. Since $c \in (\Pi_B(I_{Pat} = I), \Pi_B(I_{Pat} = \phi))$ and $\Pi_B(I_{Pat})$ is decreasing in I_{Pat} (see *Lemma*), there exists a threshold value $\hat{I}_{Pat} \in (\phi, I)$ such that if A publishes at least $\hat{I}_{Pat}$, B will invest in the cumulative invention. Therefore, if A chooses the strategy $\hat{I}_{Pat}$, she will obtain a payoff of:

$$\Pi_A(\hat{I}_{Pat}) = p = r_A(\hat{I}_{Pat}) + (1-\theta) \cdot \left[R - \left(r_A(\hat{I}_{Pat}) + r_B(\hat{I}_{Pat})\right)\right].$$

If $\Pi_A(\hat{I}_{Pat}) > r_A(I_{Pat} = I)$, then A will prefer to publish, rather than patent, some of the information. The condition $\Pi_A(\hat{I}_{Pat}) > r_A(I_{Pat} = I)$ is more likely to be satisfied when R is larger and θ is smaller. Q.E.D.

The Proposition demonstrates that when the combined value of the original and cumulative innovations, R, is sufficiently large, the initial inventor, A, would prefer to publish, rather than patent, part

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[104] This assumption implies that for any I_{Pat}, $\Pi_A > r_A$ and $\Pi_B > r_B$.

[105] B cannot issue a patent on I_{Pub}. In fact, generally, publishing, rather than patenting, I_{Pub} will not increase B's set of patentable claims. The fact that I_{Pub} is not protected, however, may increase the value of B's patentable claims.

of the original discovery. The proposition further demonstrates that A would be more likely to publish, rather than patent, when θ is low, that is, when A has more bargaining power.