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THE VALUE OF GIVING AWAY SECRETS

Oren Bar-Gill
Gideon Parchomovsky

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THE VALUE OF GIVING AWAY SECRETS

*Oren Bar-Gill** and *Gideon Parchomovsky***

ABSTRACT

This Essay demonstrates the strategic advantage of narrow patents and unprotected publication of R&D output. Broad patents might stifle follow-on improvements by deterring potential cumulative innovators, who fear being held up by the initial inventor at the ex post licensing stage. By opting for a narrower patent and unprotected publication, the initial patent holder commits not to hold up follow-on inventors, thus promoting sequential innovation and generating lucrative licensing fees. Counterintuitively, in cumulative innovation settings, less protection benefits the patentee. This finding may serve as a counter-force to the much-lamented "anti-commons" problem. More generally, our theory demonstrates that the divergence between private interests and social objectives - on both the static and dynamic dimensions of intellectual property -- is not as great as conventionally believed. Our theory bridges yet another gap; that between the two main theoretic strands in patent law scholarship--the property rights perspective and the information revelation perspective. It also explains the recent trend toward unprotected publication of information. Finally, we propose an important reform of the novelty requirement in patent law that would further encourage narrow patents and unprotected publication by bolstering the credibility of a patentee's commitment not to patent previously published research findings.

Keywords: Patents, Intellectual Property, Cumulative Innovation, Publication, Licensing, Hold-up.

* John M. Olin fellow in Law and Economics, Harvard Law School and Junior Fellow, the Harvard Society of Fellows.

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TABLE OF CONTENTS

Introduction	3
I. Property Rights, Information and Cumulative Innovation.....	8
II. The Original Inventor’s Strategic Choice: Publish or Patent	17
A. A Binary Example	17
B. A Continuous Choice of Patent Breadth.....	21
C. Multiple Cumulative Innovations	23
III. Normative Implications and Policy Recommendations	24
A. Social Goals and Private Objectives	24
1. Static Considerations – Limiting the Monopoly	24
2. Dynamic Considerations I – Spurring Cumulative Innovation	25
3. Dynamic Considerations II – Encouraging the Initial Inventor	26
B. The Novelty Requirement – A Modest (Yet Crucial) Reform ..	27
IV. Potential Objections	28
A. Narrow Patents without Publication.....	29
B. The Cost of Patenting	30
Conclusion.....	31
Appendix	33

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 by no means 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 1,000 companies have adopted the same strategy. The leading specialized journal, *Research Disclosure*, publishes over 400 disclosures per month, and the number is expected to rise in the future. In addition, several websites dedicated to publication of research results have been launched.² These developments have even prompted some concern that future increases in the volume of publications will dismantle the patent system.³

This Essay seeks 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 counter-intuitive notion that stronger patent protection may harm the inventor. In particular, we 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, and thereby extract the lion's share of the value created by the cumulative

¹ Richard Poynder, *On the Defensive About Invention: Patents*, FINANCIAL TIMES (LONDON), Sept. 25, 2001 at 14 quoting remarks by Helen Young, a project manager in Motorola's law department.

² *Id.* The most famous one is IP.com.

³ See Poynder, *supra* note 1.

invention. At first glance, it seems that the original inventor would favor strong patent protection that enables such rent extraction. We show, however, that often this initial intuition may be misleading.

Indeed, from an ex post perspective, the original inventor would prefer a broader patent. But, the ex post perspective is deceptive since it presumes the existence of the cumulative invention. And, the existence of the cumulative invention clearly 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. But, 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 cumulative inventors.⁴ 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.⁵

⁴ For the influence of patent breadth (i.e., the breadth of the original patent) on the division of profits between the original and cumulative innovators. *See infra* note 64.

⁵ The hold-up problem and its detrimental effects on potential cumulative innovation has been recognized in the economics literature. *See, e.g.*, Robert P. Merges & Richard R. Nelson, *On the Complex Economics of Patent Scope*, 90 COLUM. L. REV. 839 (1990); 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); Arti K. Rai, *Regulating Scientific Research: Intellectual Property Rights and the Norms of Science*, 94 NW. U. L. REV. 77 (1999) (hereinafter "Regulating"); Arti K. Rai, *Fostering Cumulative Innovation in the Biopharmaceutical Industry: The Role of Patents and Antitrust*, 16 BERKELEY TECH. L.J. 813 (2001) (hereinafter "Fostering"); James Bessen & Eric Maskin, *Sequential Innovation, Patents, and Imitation* (MIT Dept. of Economics, Working Paper No. 00-01, 2000); 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); Carl Shapiro, *Navigating the Patent Thicket: Cross Licensing, Patent Pools, and Standard Setting*, in INNOVATION POLICY AND THE ECONOMY (Adam Jaffe et al., eds., Nat'l Bureau of Econ. Research, 2001); and James Bessen, *Hold-up and Patent Licensing of Cumulative Innovations with Private Information* (Research on Innovation, Working Paper, 2002). *See also* Steven Shavell, *Economic Analysis of Property Law, Discussion Paper No. 399*, ch. 12: Property Rights in Information, 8-9, n.217 (John M. Olin Center for Law, Economics and Business, Harvard Law School, 2002; forthcoming in Steven Shavell, FOUNDATIONS OF ECONOMIC ANALYSIS OF LAW) ("The second innovator,

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.⁶ Thus, by ceding some of the bargaining surplus, the original inventor increases the potential reward for cumulative inventors as well as her own.

In our model, publication maintains a critical element of the patenting process – the dissemination of new information.⁷ However,

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 any new patent that they obtain to the pool, or rather maintain exclusive rights to the new patent. The former option clearly dilutes the incentive to innovate, by creating a situation akin to the hold-up problem. See Josh Lerner & Jean Tirole, *Efficient Patent Pools*, (Nat’l Bureau of Econ. Research, Working Paper No. 9175, 2002). See also Josh Lerner, et al., *The Structure and Performance of Patent Pools: Empirical Evidence* (mimeo, Harvard University, 2002) (“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 diluted.”) Out of the 63 patent pools studied by Lerner et al., 46 required “that their members assign their future related patents that are deemed essential to the pool.” See *id.* Table 2. However, allowing members to maintain exclusive rights to new patents creates another hold-up problem: “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.” *id.* See also Lerner & Tirole, *id.*

⁶ The potential advantage of weaker patent protection has been demonstrated by Bessen, *supra* note 5. However, Bessen treats patent strength as a policy variable, while we consider the strategic determination of patent strength by the original inventor. Bessen & Maskin, *supra* note 5, also demonstrate that initial inventors may prefer weaker patent protection in certain contexts. 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 made better off with a narrower patent....”). This result by Green and Scotchmer is discussed further in note 71, *infra*.

⁷ This critical element of patent law is manifested in the enablement requirement (i.e. the requirement that a patentee disclose the information / technology on which

while conventional wisdom views the publication that accompanies a patent as a necessary evil for the inventor, we argue that the original inventor will often find it in her best interest to publish the information, instead of securing patent protection for it. We demonstrate that publication serves as a commitment device. Publishing allows the original inventor to send a credible signal that she will not try to swipe all of the cumulative innovator's gains later, thus attracting follow-on inventions.

Moreover, publication has the salutary effect of blazing the trail for cumulative innovators. Publication of certain aspects of a discovery may hold the impetus for subsequent improvements of the original invention. Thus, publication facilitates cumulative innovation, even independently of the ex post hold-up problem.

Our analysis has several important implications for patent theory and practice. First, it calls into question the standard assumption among patent scholars and practitioners that patentees always prefer to seek broad protection. We 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. This means that for many inventors, less is actually more.

Second, and relatedly, we demonstrate that narrower patents coupled with publication align more closely inventors' profits and social welfare. It is well recognized that broad patent protection in cumulative innovation settings may impede subsequent innovation, and thus diminish social welfare.⁸ Our analysis suggests that broad

the patent is based). The rationale for this 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*, ch. 11, especially pp. 382, 386-7 (forthcoming). Clearly, this rationale for making information public extends also to unprotected publication.

⁸ See, e.g., Fritz Machlup & Edith Penrose, *The Patent Controversy in the Nineteenth Century*, 10 J. ECON. HIST. 1, 10 (1950); Merges & Nelson, *supra* note 5 (broad patent protection might stifle innovation); Suzanne Scotchmer, *Standing on the Shoulders of Giants* 5 J.ECON.PERSPECTIVES 29, 37 (1991) ("broad patent protection could discourage the development of second generation products"); Howard F. Chang, *Patent Scope, Antitrust Policy, and Cumulative Innovation*, 26 RAND. J. ECON. 34, 35 (1995) (same); Mazzoleni & Nelson, *supra* note 5, 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"); 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."). But see Edmund W. Kitch, *The Nature and Function of the Patent System*, 20 J.L. & ECON. 265 (1977) (broad patents stimulate further developments). Also, one strand of the

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.⁹

Third, we 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 stays available to all. Thus, the recent spate of publications may serve as a counter-force 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.¹⁰ By promoting cumulative innovation, the publishing

literature argues that "broad patents may be efficient if ex ante contracting is available" Gallini & Scotchmer, *id.*, at p. 68. See also Green & Scotchmer, *supra* note 6 p.31 ("we have shown circumstances in which the first patent should be broad"). There are, however, many impediments to ex ante contracting, i.e. to 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 Nancy T. Gallini & Brian D. Wright, *Technology Transfer Under Asymmetric Information*, 21 RAND. J. ECON. 147, 157 (1990); Scotchmer, *infra*, at 36 n.11; Chang, *infra*, at p. 38 n. 6; Heller & Eisenberg, *supra* note 5; Mazzoleni & Nelson, *supra* note 5; Bessen & Maskin, *supra* note 5; Bessen, *supra* note 5; and Gallini & Scotchmer, *id.*, at pp. 68-69. 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 5, regarding the low royalty rates charged by AT&T for the use of the patents it held on transistor technology.

⁹ See Part III *infra*.

¹⁰ See notes 81-82 *supra*.

strategy increases the return from investment in the initial invention, and thus raises the probability that the initial discovery will be made.

Finally, we propose amending the novelty requirement in patent law. Currently, 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 from 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 prevent abuse, the law should allow inventors to commit credibly not to patent research results that they first choose to publish.

The remainder of this Essay is organized as follows. Part I lays 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 then analyzes the theoretical underpinnings of this new paradigm, and – through an examination of a detailed example of cumulative innovation – define the conditions under which narrow patents and unprotected publication emerge as the dominant strategy. Part III explores the normative implications of the analysis, and derives policy recommendations. Part IV discusses and assesses 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 primarily concerned themselves with the grand challenge of justifying patent protection.¹¹ The standard justification is that property rights in inventions are necessary to provide inventors with an incentive to innovate.¹² Absent property right protection copiers would be able to appropriate the valuable information embodied in inventions without incurring the considerable costs of research and development.¹³ In

¹¹ 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).

¹² 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 R&D expenses).

¹³ 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 (2001) (noting that “the incentive theory correctly states that patent

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 an underprovision problem, stemming from the positive externalities produced by information goods.¹⁴ 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 the social deadweight loss and the administrative costs generated by it.¹⁵

Lately, a second camp, albeit a smaller one, 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. Gideon Parchomovsky, and subsequently Doug Lichtman et al, have highlighted the ability of patent races to prompt disclosure of 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.¹⁶ In a similar vein, John Thomas has proposed the use of bounties to induce the public to disclose prior art to the Patent and Trademark Office in order to improve the quality of reviewing patent applications.¹⁷ Finally, Clarissa Long, has espoused the theory that patents are merely informational signals that provide firms with a credible and cost-effective way of conveying information to third parties both about the invention and the firm itself.¹⁸

Curiously, the two scholarly perspectives seem to coexist alongside one another as though they are not related.¹⁹ Yet, they are, and in a very profound way. Moreover, neither perspective provides

protection stimulates private investment by warding off low-cost imitators and promising monopolistic profits that will at least cover product development costs.”)

¹⁴ 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 43 (5th ed. 1998).

¹⁵ Merges and Nelson dubbed this body of scholarship, “the two-dimensional analysis of incentives and deadweight loss.” Merges & Nelson, *supra* note 5. For a powerful critique of the incentive theory see Jonathan M. Barnett, *Private Protection of Patentable Goods* (unpublished manuscript) (on file with authors).

¹⁶ See Gideon Parchomovsky, *Publish or Perish*, 96 Mich. L. Rev. 926 (2000) (discussing preemptive publications); Douglas Lichtman, Scott Baker & Kate Krauss, *Strategic Disclosure in the Patent System*, 53 VAND. L. REV. 2175 (2000) (same).

¹⁷ 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).

¹⁸ See Clarissa Long, *Patent Signals*, 69 U. CHI. L. REV. 625, 636-37 (2002) (presenting the signaling theory of patents).

¹⁹ For example, Long, in setting the floor for her theory of patents as signals simply brackets out the property rights perspective. See *id.* at 637.

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 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."²⁰ 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. Information – the perennial public good – can no longer be fully controlled by the original inventor once it is disclosed.²¹ Patents, like other property rights,²² internalize the positive externalities flowing from inventions, and allow the inventor to license the invention to the third parties.²³

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

²⁰ 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).

²¹ 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 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, 9 (1966) (quoting VI Writings of Thomas Jefferson, at 180-81 (Washington ed. 1903)).

²² See Harold Demsetz, *Toward a Theory of Property Rights*, 57 AM. ECON. REV. 347, 359 (1967).

²³ *Id.*

even without patent protection,²⁴ 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 sales of the patented product. This method is very common in the pharmaceutical industry. Pharmaceutical companies derive the lion's share of their profits by selling patented drugs to consumers. The third, and final, way is 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 come up with improvements on the original invention. According to a recent report, "companies are more willing than ever before to buy rights to knowledge,"²⁵ and, in 1998 alone, "U.S. companies earned \$100 billion from licensing fees."²⁶

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.²⁷ Importantly, cumulative innovation is omnipresent, and is far more common 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."²⁸ Cumulative innovation is the hallmark of high-tech industries such as computer software,²⁹ semiconductors,³⁰ molecular biology,³¹ and pharmacology.³² However, it is by no means limited to the high-tech sector. More traditional industries, such as automobiles and aircraft,

²⁴ 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, 247 (1998).

²⁵ Edward Kahn, *Patents Recognizing and Licensing IP: Why It's Important for Small Companies*, 7 THE INTEL. PROP. STR. 8.

²⁶ *Id.*

²⁷ Examples of industries in which innovation is discrete include toys, consumer goods packaging, and power hand-tools. *See* Merges & Nelson, *supra* note 5.

²⁸ Scotchmer, *supra* note 8 at 29.

²⁹ *See e.g.* Julie E. Cohen & Mark A. Lemley, *Patent Scope and Innovation in the Software Industry*, 89 Calif. L. Rev. 1, 5 (2001) (pointing out that the software industry "is characterized by rapid sequential innovation.").

³⁰ *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).

³¹ Scotchmer, *supra* note 8 at 29.

³² *Id.*

are also characterized by cumulative innovation,³³ and the chemical industry displays attributes of “both discrete and cumulative models.”³⁴

According to Scotchmer, 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.³⁵

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 approach the end of their patents. They, then, remove the side-effects and patent the results.³⁶ In other cases, cumulative innovation leads to path-breaking results. A famous historic example is the evolution of the railroad industry.³⁷

While commentators have noted the ability of initial inventors to suppress follow on innovation by refusing to license their technologies,³⁸ they have largely ignored the reverse possibility of initial inventors opting to facilitate subsequent innovation.³⁹ 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;⁴⁰

³³ See Merges & Nelson, *supra* note 5 at 880-81 (discussing cumulative innovation in the automobile and aircraft industries). See also Jacob A. VanderMeulen, *THE POLITICS OF AIRCRAFT* 19 (1991).

³⁴ Michael A. Carrier, *Unraveling the Patent-Antitrust Paradox*, 150 U. PA. L. REV. 761, 830 (2002)

³⁵ Suzanne Scotchmer, *Cumulative Innovation in Theory and Practice*, GSPP Working Paper 240, U.C. Berkeley, at 16-18 (February 1999), available at <http://socrates.berkeley.edu/~scotch/ip.html>.

³⁶ *Face Value: Bulls, Pills And Patents*, *ECONOMIST* at 69 (June 28, 1997).

³⁷ See generally, Jacob Schmookler, *INVENTION AND ECONOMIC GROWTH* (1967).

³⁸ See, e.g., Merges & Nelson, *supra* note 5.

³⁹ The exception is Robert Merges' work on patent pools. See Robert P. Merges, *Contracting into Liability Rules: Intellectual Property Rights and Collective Rights Organizations*, 84 CAL. L. REV. 1293, 1319-23 (1996).

⁴⁰ 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. 1, 1997, at A1. The term “creative destruction” originates with Joseph Schumpeter, who used it to describe the process by which

the cost of the latter is that it makes it easier for licensees to beat the initial patentee in races for subsequent improvements.

The story of Sony's Betamax, a classic business school case study, illustrates the pros and cons of the two options. Sony has always prided itself on being a cutting edge innovator. Perceiving itself as a leader, Sony has adopted a strong proprietary philosophy marked by reluctance to widely license its technology. While in many cases, the strong proprietary approach worked out well, in one important case it has backfired. In 1975, Sony developed its own videocassette recording (VCR) format, Betamax. A year later, in 1976, Matsushita introduced a competing VCR standard, VHS. Betamax was better than the competing standard, VHS; it was also more expensive, and more tightly controlled. Sony failed to persuade enough other manufacturers to adopt the Betamax standard. Matsushita, by contrast, thanks to a powerful alliance with RCA, was able to license its VHS format more widely than Sony. Gradually, the VHS standard began to develop network effects, and new products adopted that standard. In 1988, Sony announced it would abandon the Betamax standard, and make only VHS machines; its market share at the time stood at 5 percent.⁴¹

The Sony Betamax case forcefully demonstrates the less-is-more idea. Sony's strong proprietary philosophy ended-up depriving Sony from significant profits, while Matsushita's liberal licensing strategy won the day. The revenues that an initial inventor can derive from cumulative innovation via licensing may easily trump the profits that the initial inventor can secure on its own without licensing out her technology. Although the right to exclude is thought-of as the most important stick in the property owner's bundle of rights,⁴² in fact facilitating rather than excluding cumulative innovation will often be in the best interest of the initial patent holder.

The power of the recent ascent of the open source, or free, software movement amply demonstrates the appeal of inclusive property regimes.⁴³ Despite the title, the free software movement is predicated on traditional modes of intellectual property protection,

new technologies replace older ones. See Joseph Schumpeter, *CAPITALISM, SOCIALISM, AND DEMOCRACY* 83 (1950).

⁴¹ David E. Whiteside & Otis Port, *Sony Isn't Mourning The 'Death' Of Betamax*, *Bus. Week*, Jan. 25, 1988, at 37.

⁴² See, e.g., J.E. Penner, *The "Bundle of Rights" Picture of Property*, 43 *U.C.L.A. L. REV.* 711, 734 (1996). For discussion of the "bundle of rights" theory of property see generally, Lawrence C. Becker, *PROPERTY RIGHTS: PHILOSOPHIC FOUNDATIONS* 11-21 (1977); Stephen R. Munzer, *A THEORY OF PROPERTY* 22-36 (1990); Jeremy Waldron, *THE RIGHT TO PRIVATE PROPERTY* 47-53, 59-60 (1988).

⁴³ 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).

namely copyright,⁴⁴ and to a lesser extent, patent.⁴⁵ However, the proprietors of the code 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 of the free software projects are distributed, employs a dual mechanism for enforcing compliance with community norms.⁴⁶ First, it retains in the original creator 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,⁴⁷ which mandate 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.”⁴⁸

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,⁴⁹ teaches that reducing the cost of access 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. Having generated upwards of \$155 million,⁵⁰ the Cohen-Boyer patent is considered one of the most valuable inventions in history. The immense success of the invention

⁴⁴ 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.”).

⁴⁵ Yodaiken Unveils RTLinux Patent License, Jan. 30, 2001, at <http://www.linuxdevices.com/news/NS4426144266.html> (explaining the licensing procedure for a proprietary version of Linux). See also RTLinux Is Patented?, Feb. 9, 2000, at <http://www.linuxdevices.com/news/NS2253476419.html> (allowing 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).

⁴⁶ See McGowan, *supra* note 44, 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.”)

⁴⁷ See GNU General Public License, at <http://www.gnu.org/copyleft/gpl.html> (explaining in the preamble, the terms connected to redistribution of software code). See also McGowan, *supra* note 40, at 255.

⁴⁸ See GNU General Public License, *supra* note 47. See also McGowan, *supra* note 44, at 255.

⁴⁹ See Benkler, *supra* note 43, at 371.

⁵⁰ See Kenneth Sutherland Dueker, *Biobusiness on Campus: Commercialization of University-Developed Biomedical Technologies*, 52 FOOD & DRUG L.J. 453, 492 tbl. 12 (1997).

is due in large part to the inventors' decision to ensure wide licensing of the patent by charging an extremely low fee of \$10,000. Consequently, even foreign companies that would normally run the risk of infringing elected to license the patent.⁵¹ 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.⁵²

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; and in particular to opt for facilitation via low licensing fees whenever such a strategy is privately optimal.

However, this apparent appeal of broad IP protection is misleading. The problem is that it will often be difficult for the owner of a broad patent to 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. Without a commitment 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 now in the mercy of the initial inventor.⁵³ And, anticipating such ex post hold-up, many potential improvers will be reluctant to invest in cumulative innovation.⁵⁴

This cost of broad patent protection helps reconcile the common view that strong patent protection hinders cumulative innovation,⁵⁵

⁵¹ CITE

⁵² Peter Mikhail, *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).

⁵³ We further elaborate on this hold-up problem below. See Part II, *infra*.

⁵⁴ See also Part II, *infra*. 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 also note 57, *infra*.

⁵⁵ See, e.g., Rai, *Fostering*, *supra* note 5 (providing examples of how patent protection stymies cumulative research in biotechnology); Bessen & Maskin, *supra* note 5, at 2 (finding that empirical evidence and theory both demonstrate that strong patent protection of computer programs lessens innovation); Merges & Nelson, *supra* note 5, at 884-94 (discussing the adverse effects of broad pioneer patents on subsequent innovation in the electrical lighting, automobile, airplane, radio, and semiconductor industries); Kenneth W. Dam, *The Economic Underpinnings of Patent Law*, 23 J. Legal Stud. 247, 253 (1994) (noting that broad patents inhibit future innovation). The most famous historic example of that is Thomas Edison's broad patent on the use of carbon filament as a source of light slowed down the rate

with the claim that the owner of a broad patent can simply set a low license fee. Strong patent protection, by precluding the possibility of ex ante commitment to a low licensing fee, hinders cumulative innovation.⁵⁶ This cost of broad patent protection suggests the potential superiority of an alternative strategy – narrow patents coupled with unprotected publication.⁵⁷

The conventional wisdom assumes that *all* patentees would always want the broadest patents they can obtain.⁵⁸ There is no reason why this should be true, however. Recognizing the tradeoff between the current advantage of broad protection and future profits from

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* 91-93 (1949).

⁵⁶ 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. However, we demonstrate that the divergence between private interests and social objectives is not as deep as conventionally believed. See Parts II and III, *infra*.

⁵⁷ In certain specific cases, the initial patent holder may be able to commit to setting a low licensing fee, even with a broad patent. This possibility may arise when the initial patent holder is a repeat player dealing with many similarly positioned sequential innovators. Under such 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. See also note 54, *supra*. The open source movement has similarly been successful in committing to a low, in fact to a zero licensing fee. However, it seems that problem of inducing ex ante investments in the sequential improvements is of a lesser importance in the open source context. See, generally, Benkler, *supra* note 43.

⁵⁸ See e.g. Cohen & Lemley, *supra* note 29, 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 PTO of the most broadly worded claims possible."). It has also been argued that strong IP 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. _ (forthcoming May 2003).

cumulative innovation, some initial patentees should be expected voluntarily to cede some protection 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: it determines the breadth of the patent, and it can substantially reduce the cost of follow on innovation.

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

Moreover, the information disclosed in publications lowers R&D costs for cumulative innovators, and can attract them to pursue improvements to the original invention. Given that innovation is highly path dependent,⁵⁹ the provision of free research leads may attract cumulative innovators to improve on the patented inventions of the publishing firm.⁶⁰

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

⁵⁹ 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).

⁶⁰ For a detailed discussion see Part IV, *infra*.

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 patent and a narrow patent. Then, 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. This breakthrough is valuable in itself, but the bulk of 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 her new technology, she will enjoy a payoff of 400 from her original invention. On the other hand, A can choose to seek a narrow patent, covering only part of her discovery, and publish part of the discovery without IP protection. Assume that the narrow patent will generate a lower payoff of 200 from the original invention.⁶¹ Clearly, focusing only on the revenues that can be generated from the original discovery, A would prefer a broader patent. However, as noted above, 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.⁶² If

⁶¹ Since 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. 113-130 (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. 106-112 (1990) (stating that patent breadth is measured by the price that the patent holder can charge for the patented product); Shavell, *supra* note 5, ch. 12, p. 7 (“Issues of the scope of protection are exemplified by whether a closely-related improvement on a patented invention will be considered infringing.”).

⁶² We focus on cumulative innovation by other inventors, i.e. 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 8, 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

cumulative inventions are expected to appear regardless of A's strategic patent or publish choice, then again a broad patent is optimal for A. But, cumulative inventions 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 these investments will be made.

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 innovation 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. Specifically, 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 patent (with the ensuing publication) or publish 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. Obviously, 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 lion's share of the value created by the cumulative invention lies in the combination of B's development with A's initial discovery. And, to realize this value, B will need to negotiate a license with A.⁶³ For simplicity, we assume that B's cumulative invention is

consider them... [C]reativity is largely serendipitous. Not every R&D firm sees the same opportunities for new products.”).

⁶³ 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.*, Scotchmer, *supra* note 8, at 33-4, 38 (“The breadth of the prior patent determines the probability that the second generation product will infringe.”); Gallini & Scotchmer, *supra* note 8, 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.”). 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 5 (“the

valueless on its own, but can produce revenues of 1000 when combined with A's original discovery.

B's considerations are directly affected by A's strategic choice between patenting and publishing her original discovery. A's strategy determines the parties' relative positions in the licensing negotiations, 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.⁶⁴

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.⁶⁵ 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.⁶⁶ From B's perspective, at the ex post bargaining stage, B's

sequential innovator" might undertake additional development efforts to "invent around" the patent.").

⁶⁴ 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.,* Scotchmer, *supra* note 8, at 32, 34, 36 ("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."); Green and Scotchmer, *supra* note 6, at 21, 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."). *See also* Chang, *supra* note 8, at 43 ("The court's decision [regarding antitrust regulation and patent scope] would set the threat points 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 (e.g. various damage measures or injunction). *See* Mark Schankerman & Suzanne Scotchmer, *Damages and Injunctions in Protecting Intellectual Property*, 32 RAND J. ECON. 199-220 (2001).

⁶⁵ A's strategy can also affect the value of B's outside option. This extension is analyzed in the appendix.

⁶⁶ 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 components. One component will dissipate following the introduction of a new product based on the combination of the original and cumulative inventions. A second component 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 component, 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, e.g. the LCD screen, and B (or several B's) may develop application (or

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.⁶⁷ Assume that A and B have equal bargaining power,⁶⁸ 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.⁶⁹

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, leaving B with a revenue of $1000 - 600 = 400$, which is sufficient to cover B’s ex ante investment.⁷⁰

applications) for this basic technology, e.g. a digital watch, a digital phone, etc. (*see* subsection C, *infra*). 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, by the time A invents around B will have gained control of the relevant market, or B’s product will drive out A’s inferior application).

⁶⁷ On the determinants of bargaining power, specifically patience (or, in economic terms, a party’s discount rate). *See* Ariel Rubinstein, *Perfect Equilibria in a Bargaining Model*, *Econometrica*, 50, 97-109 (1982). *See also* DREW FUDENBERG, & JEAN TIROLE, *GAME THEORY* 113-7 (MIT Press, Cambridge, MA, 1991); MARTIN J. OSBORNE & ARIEL RUBINSTEIN, *A COURSE IN GAME THEORY* 126-7 (MIT Press, Cambridge, MA, 1994).

⁶⁸ This assumption is made only for clarity of exposition. *See also* Green and Scotchmer, *supra* note 6, at 24; Chang, *supra* note 8, at 43. We relax this assumption in the formal analysis, which is provided in the appendix.

⁶⁹ Rai, *Regulating*, *supra* note 5, at 70, discusses an example of holdup 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 original 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.” *See also* Rai, *Fostering*, *supra* note 5, at 835.

⁷⁰ This analysis borrows from the Property Rights theory in economics. *See, e.g.*, OLIVER HART, *FIRMS, CONTRACTS, AND FINANCIAL STRUCTURE* ch. 2 (Oxford University Press 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 for a narrower patent – thus affecting the value of her outside option, and consequently

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.⁷¹

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 narrowest possible patent) and 400 (the broadest possible patent), as a stand-alone invention (i.e. 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. 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

the bargaining outcome. See also Sanford Grossman & Oliver Hart, *The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration*, 1986 J. POL. ECON. 94; Oliver Hart & John Moore, *Property Rights and the Nature of the Firm*, 1990 J. POL. ECON. 98.

⁷¹ Focusing on ex ante contracting, rather than on ex post licensing, Green and Scotchmer, *supra* note 6, at 31 also find that the initial inventor may prefer a narrower patent. In the same spirit, Schankerman and Scotchmer, *supra* note 64, 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, thus enhancing the bargaining power of the cumulative innovator.

invest in a cumulative invention if and only if $500 - \frac{1}{2} \cdot r_A - c > 0$, i.e. 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:

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

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.

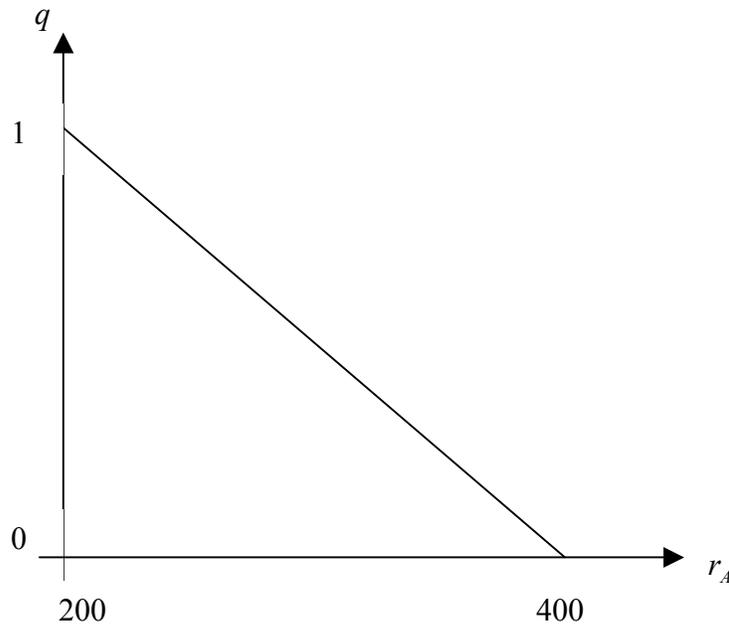


Figure 1: Patent breadth and the likelihood of cumulative innovation

As illustrated in figure 1, the likelihood of cumulative innovation is decreasing in the breadth of the patent on the original invention.

However, the reduced likelihood of cumulative innovation 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. On the other hand, if B decides not to invest in the cumulative invention, A must settle for her outside option, r_A . Therefore, A's ex ante expected profit equals:

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

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 $500 + \frac{1}{2} \cdot r_A$. And, 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, i.e. by choosing a smaller r_A .⁷³ As a result, A will opt for the narrowest possible patent, $r_A = 200$.⁷⁴

C. Multiple Cumulative Innovations

⁷² In our example $500 + \frac{1}{2} \cdot r_A > r_A$, so that A always prefers the license fee, $500 + \frac{1}{2} \cdot r_A$, over her outside option, r_A .

⁷³ 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, i.e. $r_A = 200$.

⁷⁴ 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.

For expositional purposes, the preceding analysis assumed a single cumulative innovator. Yet, often, a single initial invention can spur multiple sequential developments. In such cases, the appeal of the publishing strategy may be significantly enhanced.

Return to the basic Section A model, but rather than a single cumulative innovator, B, 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 400. However, if the initial inventor opts for a narrow patent, 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 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 literatures teach that intellectual property, 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 even fail to induce investment in a socially desirable initial invention, since the patent holder generally will not be able to appropriate the entire surplus created by the stream

of products that builds on her initial invention.⁷⁵ 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.⁷⁶ While *ex ante* IP protection 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 all the inefficiency this entails. In particular, the monopolist will charge a higher price and will produce a lower quantity as compared to the social optimum.⁷⁷

These costs of IP protection are increasing in the strength of the patent-holder's monopoly, i.e. in the breadth of the patent. As a result, calls for limiting the breadth of patent protection are often heard. Our analysis suggests that legal reform imposing narrow patents may not be necessary. 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 will often 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.⁷⁸

⁷⁵ 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.

⁷⁶ See, e.g., Landes and Posner, *supra* note 7, at 383 (pointing out the “danger that the inventor will be enabled to charge a higher price than he needs to recover the fixed costs of his invention, thereby restricting access to the invention more than is necessary.”); Shavell, *supra* note 5, ch. 12, p. 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.”).

⁷⁷ See, generally, ANDREU MAS-COLELL, MICHAEL D. WHINSTON & JERRY R. GREEN, MICROECONOMIC THEORY 384-7 (1995).

⁷⁸ Put differently, a narrow patent limits the monopoly power of the original inventor, and thus reduces the deadweight loss associated with the patent monopoly. It should be noted, however, that once the cumulative invention is developed and combined with the original discovery, a more powerful monopoly might result. Still,

2. Dynamic Considerations I – Spurring Cumulative Innovation

Conventional wisdom suggests that initial inventors will opt for broad patents, thus hindering technological progress via cumulative innovation. 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, will often 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.⁷⁹

At the policy level, this finding cautions against proposals to limit patent breadth in the name of cumulative innovation. Imposing such limits is not necessary when the initial innovator has a private interest to refrain 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.⁸⁰

The increased willingness to publish research findings is bound to 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 counter-force 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 increased surplus created by cumulative innovation will generally outweigh the deadweight loss generated by this monopoly.

⁷⁹ 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 (compare to the problem of excessive and duplicative investment in the patent race context).

⁸⁰ See also subsection 3, *infra*.

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. However, 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.⁸¹ Hence, if the initial inventor cannot extract enough surplus from the sequential innovators, she might not develop the basic invention.⁸² 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.

B. The Novelty Requirement – A Modest (Yet Crucial) Reform

The preceding analysis has demonstrated the private, as well as the social value inherent in the publishing strategy. The ability of the initial inventor to commit a higher share of the surplus to the 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.

⁸¹ “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 8, at 65.

⁸² See Green and Scotchmer, *supra* note 6, at 20 (“[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 application 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.”) See, e.g., Scotchmer, *supra* note 8, at 30 (“proper 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 8, *id.* (same); Shavell, *supra* note 5, ch. 12, p. 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. And, 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, Scotchmer, *supra* note 8, *Id.*, and Gallini & Scotchmer, *supra* note 8, *Id.*

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 from the date of publication. Moreover, patent applications are published eighteen months after filing date.⁸³ Therefore, theoretically, an initial patent holder may publish information on January first 2004, file for a patent on December 31st 2004, and this filing will be made public only on June 30th 2006. Only if the sequential innovator makes his investment decision after June 30th 2006, i.e. two and a half years after publication by the initial inventor, can he be certain that the initial inventor will stick to the narrow patent,⁸⁴ leaving the previously published information in the public domain.

But, opportunities for cumulative innovation can present themselves before June 30th 2006. In many industries two and half years is a very long time. And, one of the central advantages of the publishing strategy is to spur rapid technological progress. Arguably, the initial patent holder, in her January 1st 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 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.

⁸³ Moreover, the patent applicant can prevent publication of the patent application even after the 18 months period. *See* 35 USCS § 122 (b)(2)(B) ("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).")

⁸⁴ In theory a potential cumulative innovator can approach the initial inventor and request – (1) a formal contractual obligation that the initial inventor will not to file a patent application with respect to the published information (in the first year following the publication); or (2) a signed affidavit that the initial inventor has not already filed such a patent application (after the first year following the publication has ended). 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 further invest in exploring on her own the potential applications of the published information (potentially leading to the filing of a patent application by the initial inventor, if the one-year post-publication period has not ended), to the detriment of the cumulative innovator.

Thus, to realize the full beneficial effect of publications, and prevent abuse, the law should allow inventors to commit credibly not to patent research results that they first choose to publish.⁸⁵ This socially desirable result can be readily implemented by affecting a relatively minor amendment to the novelty requirement in patent law: prior publication - including publication by the patent applicant herself - should be considered prior art that prevents patent protection under the novelty requirement.

IV. POTENTIAL OBJECTIONS

In this part, we take issue with two potential objections to our analysis. First, we consider the argument that narrow patents without publication provide an equally good mechanism to entice 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: 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 down the scope of the patent is likely to get lost on account of 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

⁸⁵ Importantly, we propose to *enable* commitment to refrain from patenting, not to force inventors into such a commitment. Hence, our proposal cannot be criticized as deterring inventors, who do plan on patenting their discoveries, from early publication.

thereby, keep all 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.⁸⁶

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 as to 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 non-trivial.⁸⁷ 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 may make no economic sense to pursue patent protection for relatively modest technological advancements. However, failure to patent runs the risk that a competitor would 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.”⁸⁸ By virtue of this section,

⁸⁶ 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 to describe it. See Anthony J. Trippe, *Searcher Patinformatics: identifying haystacks from space*, 10 SEARCHER 28 (2002).

⁸⁷ See e.g. Wayne M. Kennard, *Software Patents and the Internet*, 610 PLI/Pat 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 L 10, 11 (June 2000) (reporting that the cost of obtaining a patent may range between \$6,400 and \$30,300).

⁸⁸ 35 U.S.C.A. § 102(b) (West 2000).

publication may be used as a defensive mechanism that restricts the ability of rival firms to appropriate certain information the publishing firm discovered first but elected not patent.⁸⁹

While we do not dispute that concern with cost may lead firms to publish defensively, we contend that cost based arguments cannot, on their own, 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 Patent Office--\$710 to file an application and \$1240 to issue an approved patent application.⁹⁰ 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.⁹¹

A second problem with the cost based story is that it is internally inconsistent. Recall that under § 102 (b) of the Patent Act, any publication in the U.S. or abroad may bar a patent from being issued to a competitor. Construing the provision extremely broadly, in *In Re Hall*,⁹² the Federal Circuit held 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 formally put the information in the public domain without making it accessible to competitors.⁹³ From a cost based perspective, such strategic publication dominates regular publication since it induces rival firms to continue to expend valuable resources on R&D on the false belief that they can get the

⁸⁹ For discussion of defensive, or preemptive, publication see Parchomovsky, *supra* note 16; Lichtman et al, *supra* note 16. Cf. Rebecca S. Eisenberg, *The Promise and Perils of Strategic Publication to Create Prior Art: A Response to Professor Parchomovsky*, 98 Mich. L. Rev. 2358 (2000).

⁹⁰ See Fees and Payment of Money, 37 C.F.R. §§ 1.16(a), 1.18(a) (2000). For a detailed discussion of the aggregate cost of applying for patents see Thomas, *supra* note 17, at 345.

⁹¹ 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.").

⁹² 781 F.2d 897 (Fed. Cir., 1986).

⁹³ See Daniel Levi-Mazloum & Thomas von Ungern-Sternberg, *To Patent or to Publish*, 2 SMALL BUSI. ECON. 191 (1990) (discussing the implications of this possibility).

results patented. 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 research and development progress does not hinge entirely, or even in any 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 of revenues. 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, thus 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 information set I . Next, at $T=1$, A chooses the breadth of the patent protection that she will claim on her discovery, i.e. 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, $I_{Pat} \cap I_{Pub} = \emptyset$ 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. However, even if B decides to invest c and obtains a patent on the cumulative innovation, still B 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 at $T=3$ B approaches A, 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} .⁹⁴

Under these assumptions, B will pay

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

⁹⁴ The analysis can be readily extended to allow for the investment c to depend on I_{Pat} .

for the license, where $\theta \in [0,1]$ represents B's bargaining power, and $1-\theta$ represents A's bargaining power.⁹⁵ 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:

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

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} .⁹⁶

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 –

- 1) By patenting less and publishing more, A improves B's outside option, thus reducing p and increasing Π_B .⁹⁷
- 2) 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.

⁹⁵ When B has all the bargaining power, i.e. $\theta = 1$, he will only pay A the value of her outside option, r_A . When A has all the bargaining power, i.e. $\theta = 0$, she will extract from B a price of $R - r_B$, leaving B with only the value of B's outside option, r_B .

⁹⁶ This assumption implies that for any I_{Pat} $\Pi_A > r_A$ and $\Pi_B > r_B$.

⁹⁷ 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. However, the fact that I_{Pub} is not protected may increase the value of B's patentable claims.

Proof: With no publishing, i.e. 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 $c \in (\Pi_B(I_{Pat} = I), \Pi_B(I_{Pat} = \phi))$, 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:

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

If $\Pi_A(\hat{I}_{Pat}) > r_A(I_{Pat} = I)$, then A will prefer to publish (rather than patent) some of the information. QED

This result implies 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 of the original discovery.