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Gideon Parchomovsky

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# PUBLISH OR PERISH

Gideon Parchomovsky\*

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## INTRODUCTION

The race model has been the darling of patent economists and game theorists.<sup>1</sup> This model assumes that the winner, namely the first to invent, takes the patent grant with the market dominance that comes with it, whereas the second comer, in the best tradition of sports contests, obligingly accepts her loss and quietly vanishes from the scene. While the sports analogy has provided a useful framework for understanding the economics of invention, it has obfuscated an important aspect of the inventive process: the possibility of strategic publication of research findings in order to prevent the issuance of a patent to a competitor. Captured by the sports analogy, patent scholars have consistently presupposed that the loser of a patent race must behave in a sportsmanlike fashion and gracefully accept her fate. But

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1. See, e.g., JEAN TIROLE, *THE THEORY OF INDUSTRIAL ORGANIZATION* 394-414 (1988); ERIC RASMUSEN, *GAMES AND INFORMATION* 341-48 (2d ed. 1994); see also Giovanni De Fraja, *Strategic Spillovers in Patent Races*, 11 INT'L J. INDUS. ORG. 139 (1993); Jennifer F. Reinganum, *A Dynamic Game of R&D: Patent Protection and Competitive Behavior*, 50 ECONOMETRICA 671 (1982); Partha Dasgupta & Joseph Stiglitz, *Uncertainty, Industrial Structure, and the Speed of R&D*, 11 BELL J. ECON. 1 (1980); Tom Lee & Louis L. Wilde, *Market Structure and Innovation: A Reformulation*, 94 Q.J. ECON. 429 (1980); Glenn C. Loury, *Market Structure and Innovation*, 93 Q.J. ECON. 395 (1979).

there is no reason whatsoever why competition in the inventive field should conform to the rules of sports.<sup>2</sup>

The stakes and payoff matrices of patent races are considerably different from those of sports contests, and, thus, it is only natural to expect firms in a patent race to deviate from the norms of fair competition in sports. The nature of patent races is much more complex than that of other races. Ceding a patent to a competitor may often spell a substantial drop in revenues for the losing firm, and in some cases may even drive the loser out of the market.<sup>3</sup> Therefore, trying to win the race may not always be the profit-maximizing strategy. Rather, in many patent races the superior strategy for one or more of the competing firms would be to prevent other firms from winning the race by publishing their research findings. Recharacterizing patent races in this way implies that firms that are about to lose in a patent race often face a dilemma all too familiar to academics, the choice of "publish or perish."

The possibility of preemptive publication inheres in every patent system. The point and purpose of the patent grant is to reward innovation.<sup>4</sup> Yet, not all types of innovation are eligible for reward: only inventions that constitute a nontrivial contribution over the prior art qualify for patent protection.<sup>5</sup> This trait of patent protection introduces an important element of relativity into the patent system, turning the prior art into the reference point against which new patents are evaluated. Thus, firms have the power to affect the patentability of their rivals' inventions by altering the state of the prior art. Because any publication immediately becomes part of the prior art, the strategy of preemptive publication allows a firm to render an otherwise nonobvious invention obvious and, as a result, unpatentable. Returning momentarily to the sports analogy, it can be said that preemp-

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2. Preemptive publication may also be useful to firms — whether in a race or not — that do not wish to incur the considerable cost of obtaining a patent, but want to retain free access to their R&D. In the same vein, preemptive publication is useful to firms estimating that a competitor is about to patent one of the publishing firm's trade secrets. Publishing, in this case, will enable the firm to keep using the process or innovation.

3. A case in point is the famous race between Amgen and Genetic Institute over the exclusive right to market erythropoietin (EPO) in the United States. Each of the companies patented the technique it developed for producing EPO and sued the other for infringing its patent. At trial, the court held the patents of both companies not invalid and infringed. *See Amgen, Inc. v. Chugai Pharm. Co., Ltd.*, 706 F. Supp. 94 (D. Mass. 1989). On appeal, the Federal Circuit reversed in part, holding that while Amgen's patent was indeed valid and infringed, Genetic Institute's patent was invalid. *See Amgen, Inc. v. Chugai Pharm. Co., Ltd.*, 927 F.2d 1200 (Fed. Cir. 1991). This decision effectively granted the United States EPO market to Amgen.

4. Or, in the language of the Constitution, "[t]o Promote the Progress of Science and useful Arts." U.S. CONST. art. I, § 1, cl. 8.

5. *See Pearce v. Mulford*, 102 U.S. 112, 118 (1880) ("[A]ll improvement is not invention, and entitled to protection as such.").

tive publication shifts the goalpost of patentability, or, more accurately, raises the patentability bar.

A simple example may help illustrate the point. Assume that two firms, A and B, compete for a new computer chip. Suppose that A has an invention that is a clear improvement over prior art — say, a chip design that is 10% faster than the best chip now available. Although, in principle, A's invention is eligible for a patent, B's involvement in the race may block the patent to A. B can prevent A from obtaining the patent by publishing its design for a 5% faster chip, which, although it is not enough to procure a patent for B, is enough to block A's innovation, making it no longer a significant improvement over prior art.

The Patent Act employs two mechanisms to ensure that only inventions constituting a real inventive leap over the prior art are rewarded: novelty and nonobviousness. The novelty requirement, as embodied in § 102, denies patentability to inventions that were known, used, or described in a printed publication or a patent application at any time prior to filing.<sup>6</sup> The nonobviousness requirement, codified in § 103, reinforces the novelty requirement by limiting patentability to inventions that truly enhance social utility.<sup>7</sup> Together these requirements ensure the basic tradeoff patent law seeks to promote: disclosure of substantially new information in exchange for a limited monopoly grant. At the same time, they also enable the strategy of preemptive publication.

While the novelty and nonobviousness requirements make the strategy of preemptive publication theoretically possible, the nature of the inventive process itself makes it practically feasible. From a practical standpoint, the strategy of preemptive publication is made possible by the lag that exists between the time a firm obtains sufficient research results to effect a change in the prior art and the time it perfects the invention. Under the "first to invent" rule that prevails in the United States, the first firm to reduce an invention to practice is entitled, as a general rule, to patent protection.<sup>8</sup> An invention can be reduced to practice either constructively or actively. A constructive re-

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6. See 35 U.S.C. § 102 (1994).

7. See 35 U.S.C. § 103 (1994).

8. For a classic statement of the priority rule, see *Christie v. Seybold*, 55 F. 69 (6th Cir. 1893). Unless the inventor can prove an earlier date, the date of filing is considered the date of reduction to practice for purposes of priority. See *id.* at 75. The only exception to the general rule stated above is a case in which the second to reduce to practice can show: (1) that she conceived the invention first; and (2) that she was reasonably diligent in reducing her invention to practice. See *id.* at 76. The practical importance of the exception has proven to be rather miniscule. The process by which priority between two inventors is being determined in such cases is called "interference." Historically, only 0.1% of the applications required an interference process, and of those, the "junior party," the second to file, prevailed in fewer than 0.33%. See Ian A. Calvert & Michael Sofocleous, *Interference Statistics for Fiscal Years 1992 to 1994*, 77 J. PAT. [ & TRADEMARK ] OFF. SOC'Y 417, 421 tbl. 4 (1995).

duction to practice occurs when the patent application is filed. An active reduction requires a showing that at some earlier date the invention actually "work[ed] for its intended purpose."<sup>9</sup> Thus, a firm that elects to pursue a patent must develop a "working model" of the invention. By contrast, a firm that chooses to publish need only possess certain theoretical results that enable the invention, and sometimes even less. Any publication of results may, in principle, raise the nonobviousness standard enough to spoil a patent for a competitor.

The ability to adversely affect the patentability of rivals' inventions through publication explains the otherwise peculiar practice of commercial firms that routinely publish research results in scientific and technological journals. While firms engaging in research and development ("R&D") ultimately wish to obtain patent protection, their research results often fall short of supporting a patent application. In many cases research does lead to improvements over the prior art, but those improvements are insufficient to satisfy the nonobviousness standard. Although minor improvements over the prior art cannot secure a patent grant, they are by no means valueless. The publication of such results alters the chances of rival firms reaching the patent mark and is, thus, of value to the publishing firm.

A firm will choose to publish its research results whenever it believes — correctly or incorrectly<sup>10</sup> — that its competitors are likely to beat it to the patent application. Three reasons might account for such a belief. First, a firm may estimate that its rivals are at a more advanced stage in their research, either because they started earlier or because their human resources are superior. Second, due to imperfect

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9. *Estee Lauder Inc. v. L'Oreal, S.A.*, 129 F.3d 588, 593 (Fed. Cir. 1997). The United States is the only country in the world that follows the "first-to-invent" rule; all other countries have adopted the "first-to-file" rule, which determines priority between inventions according to the date of filing, regardless of who invented first. The United States has consistently declined the invitation to join the rest of the world by adopting a "first-to-file" rule. Yet, the pressure to effect this change persists. Several commentators have suggested that switching to a "first-to-file" rule will have virtually no practical implications. See, e.g., Gerald J. Mossinghoff & Vivian S. Kuo, *World Patent System Circa 20XX, A.D.*, 38 *IDEA* 529, 549 (1998) (arguing that "the United States now has a virtual first-to-file system"). However, switching to a "first-to-file" rule does have an important implication when the possibility of preemptive publication is considered. The "first-to-file" rule extends the period during which a preemptive publication is possible, and thus gives an advantage to intended publishers over intended patentees.

10. Because firms in a patent race operate in an environment of imperfect information, they may have an incorrect belief as to one or more of the following factors affecting the publication decision. First, a firm may wrongly believe that it is involved in a patent race, whereas in fact it is not. This can happen, for instance, when two firms compete for a new drug for treating a certain disease, but each of them is developing a different product. Second, a firm may be incorrect in assessing its ability to beat its competitors to the sought-after patent. Finally, a firm may be incorrect in overestimating the research skills, or the success, of its competitors. Therefore, a firm may sometimes decide to publish even though it is not in its best interest to do so. The possibility of reaching a mistaken decision weakens to some extent the incentive to publish, but it does not eliminate it altogether. It is just another factor a firm must take into account in deciding on an appropriate strategy.

access to financial markets, a firm may believe that other firms are able to obtain financing at a lower cost and, as a consequence, file for a patent more quickly. Finally, and relatedly, a firm may prioritize its research projects in a way that prevents it from fully engaging in a particular patent race. In all these instances a firm may find it in its best interest to become a spoiler by resorting to the strategy of preemptive publication.

Preemptive publication offers two important benefits. First, it prevents a rival firm from acquiring an important competitive edge. Preemptive publication enables the publishing firm to block a rival from obtaining a patent and thereby maintain its market position. Furthermore, if the rival firm expended more money on R&D in an attempt to win the patent race, preemptive publication would give the publishing firm a relative advantage over its competitor. Although sunk costs do not on their own affect the relative positions of the firms vis-à-vis present projects, it may affect their financial ability to engage in other research projects in the future. Second, preemptive publication allows the publishing firm to use the information it published in future projects at no cost. In the absence of such a publication, the patent bars all others from using the information disclosed in the patent application without a license from the winning firm. Preemptive publication obviates the need to negotiate such a license. Furthermore, preemptive publication makes it possible for the publishing firm to eventually obtain a patent on variants of the original invention — or, as they are called in the jargon of patent law, “improvements.”

This Article explores the strategy of preemptive publication in patent races and evaluates its welfare implications. In particular, this Article offers three novel insights. First, it demonstrates, contrary to prevailing theory, that the strategy of preemptive publication sometimes dominates the strategy of attempting to win the patent race. An important implication is that firms engaged in a patent race can make a credible threat of publishing their research results and thereby force the likely patentee to negotiate a licensing agreement with them prior to receiving the patent.<sup>11</sup> Significantly, this result alters the prevailing understanding of patent races as “winner take all” games because even second comers may indirectly obtain a share of the patent grant. Second, and relatedly, this Article shows that recourse to preemptive publication can lead to an equilibrium in which none of the competing firms receives a patent. However, no patent will issue in such cases not because the desirable invention cannot be produced, but rather because the knowledge underlying the invention had been made public before its completion. Finally, the Article argues that preemptive

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11. Such licensing agreements may have antitrust implications, depending on the importance of the invention and the market positions of the parties involved. A detailed discussion of this issue is beyond the scope of this Article.

publication is likely to promote economic efficiency in industries, such as biotechnology, that depend on access to basic research, and in network markets since it makes valuable information available to the public without the attendant cost of limited monopoly.

In addition, the normative analysis in this Article indicates that an innovation policy that overlooks the option of preemptive publication will be suboptimal in that it will set the obviousness standard too high. A high obviousness standard is socially desirable as it sifts out trivial innovations from meaningful ones, but at the same time it increases the opportunity for preemptive publication and may thus unduly diminish the incentive to innovate.

This Article proceeds in four Parts. Part I explains the economic rationale underlying preemptive publication and the legal rules enabling it. Part II constructs a formal model to explain when firms will choose to publish their research findings and then sets forth the conditions under which preemptive publication dominates the strategy of regular competition for a patent. Part III analyzes the welfare effects of preemptive publication. Finally, Part IV introduces and explores the possibility of “the double preemption twist” — a defensive maneuver in which the anticipated winner of the patent race publishes first to shield itself from preemptive publication by a rival.

## I. THE ECONOMIC AND LEGAL RULES OF PATENT RACES

The optimal strategy for a firm in a patent race is to maximize its expected profits in all possible states of the world. In the present context, the two relevant states are: a world with patent protection, and a world without. Given that the issuance of a patent is a probabilistic event that depends on the research skills of the firm, its investment level, and often on luck, no firm can rationally assume that it is going to win every patent race in which it engages. Consequently, in many cases the best strategy for firms is not to try to win every patent race they enter, but, rather, to quit the race and maximize their profits without patent protection.<sup>12</sup>

Curiously, existing models of patent races have focused exclusively on the option of winning the patent and, as a result, have overlooked the important ramifications of *losing* a patent race.<sup>13</sup> Yet, no profit-

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12. It is important to note that the investment in R&D is a sunk cost that a firm engaged in a patent race necessarily incurs regardless of the strategy it chooses to pursue.

13. Of the various race models, the most influential is the “memoryless model” of Dasgupta and Stiglitz. See Dasgupta & Stiglitz, *supra* note 1. The model assumes identical firms with continuous investment in R&D. Furthermore, it assumes that the probability of making a patentable breakthrough depends only on a firm’s *current* decisions as to R&D investment — past investments that failed to yield a patentable invention are completely wasted. Although this assumption is rather unrealistic, it has become the standard assumption in the economic literature on patent races. See De Fraja, *supra* note 1, at 141.

maximizing firm can afford to do the same — losing a patent race entails not only a loss of considerable investment in R&D, but also a substantial drop in profits because its rival can introduce a superior product in the market. Thus, at any point in time following the initial decision to join a patent race, a firm would choose to pursue the option of patenting only if it estimates that the expected payoff from patenting is higher than the expected payoff from quitting the race and publishing its research findings. Or, formally, a firm would continue in a race, IFF  $p_{win} * (\text{Net Profit}|\text{Win}) > p_{lose} * (\text{Net Profit}|\text{Lose})$ .

Importantly, a firm's probability of winning a patent race is endogenous to the race itself — victory is contingent not only on the firm's ability to successfully complete the invention, but also on its ability to do so before the other entrants in the race. Thus, the expected payoff of a firm in a patent race depends to a large extent on the research results of its rivals. Naturally, if a firm estimates that its likelihood of winning the race is higher than that of all other firms, it should *generally* compete to the end.<sup>14</sup> If, on the other hand, a firm estimates that its probability of winning is lower than that of even one of its competitors, then its optimal strategy changes radically. Rather than maximizing its investment in R&D in an attempt to preserve its lead in the race, a firm estimating that it will lose should attempt to maximize its expected profits in the absence of patent protection. Such polarized profit-maximizing strategies are dictated by the very nature of patent races, which rewards only the first-comer while offering no consolation prizes to second-comers.

Preemptive publication is probably the most powerful defensive strategy a firm can employ in the face of an imminent reduction to practice by a competitor. Rather than conceding a loss and allowing a competitor to gain monopoly power in a certain product or process market, a firm in possession of sufficient research results<sup>15</sup> can bar its competitor from obtaining the patent by publishing the information it holds. The possibility of preemptive publication derives from the very principles animating the patent system, which is predicated on a fundamental tradeoff of information for limited monopoly power.<sup>16</sup> Because patents come at a cost to society, the patent system rewards only new inventions; granting a patent to an already existing invention makes no economic sense.<sup>17</sup> Furthermore, even if an invention is

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14. The analysis in this Article shows, however, that even a firm estimating that its probability of winning is higher than that of all other firms should not always attempt to win the patent since it remains exposed to the risk of preemptive publication.

15. For a discussion of what constitutes "sufficient research results," see *infra* text accompanying notes 22-23.

16. See Rebecca S. Eisenberg, *Patents and the Progress of Science: Exclusive Rights and Experimental Use*, 56 U. CHI. L. REV. 1017, 1028 (1989).

17. See DONALD S. CHISUM ET AL., PRINCIPLES OF PATENT LAW 335 (1998).



novel, it may nevertheless be ineligible for a patent if it is anticipated by the prior art. Thus, to qualify for a patent, an invention must make a *meaningful* contribution to the existing pool of knowledge<sup>18</sup> and be considerably different from the prior art.<sup>19</sup> The Patent Act pursues this policy through the requirements of novelty and nonobviousness.

The novelty requirement denies patent protection to an invention that was known, used, or described in a printed publication, in the United States or elsewhere before the date of invention. Accordingly, any printed publication preceding the date of invention, even by the slightest of margins, will suffice to bar an invention from receiving a patent. However, a publication does not necessarily have to describe an invention identical to the one for which a patent is sought in order to block it from obtaining a patent; all that the publication must do is render the invention obvious to a person skilled in the relevant art. Aptly described as the “final gatekeeper of the patent system,”<sup>20</sup> the nonobviousness requirement withholds patent protection from minor improvements.<sup>21</sup> The nonobviousness requirement ensures that only meaningful innovation — innovation that represents a sufficiently large technical advance over the prior art<sup>22</sup> — is rewarded by the patent system. Thus, if the prior art renders a particular invention trivial, the innovation is ineligible for a patent.

The interdependence between the patentability of new inventions and the state of the prior art creates a unique opportunity for firms to affect the patentability of their rivals' invention not by competing with them “head on” for the patent grant, but rather by altering the state of the prior art. To see this clearly, it is helpful to quantify the nonobviousness requirement in terms of innovation increments.<sup>23</sup> For example, one could imagine a patent system in which inventors are required to improve upon the prior art by 10 innovation increments in order for an invention to be patentable. Under this rule, whenever a firm esti-

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18. *See id.*

19. *See id.* at 335, 531.

20. ROBERT PATRICK MERGES, *PATENT LAW AND POLICY* 479 (2d ed. 1997).

21. The nonobviousness examination, as formulated by the Supreme Court in the landmark case of *Graham v. John Deere Co.*, 383 U.S. 1 (1966), consists of three steps. First, the court has to determine “the scope and content of the prior art.” Then, it must identify “the differences between the prior art and the claims at issue.” Finally, the court has to determine the “level of ordinary skill in the pertinent art” at the time the invention was made and decide whether the claimed invention would have been obvious at the time of invention to a person of ordinary skill in the art. *Id.* at 17.

The Court added that the nonobviousness determination may be aided by “secondary considerations” such as “commercial success, long felt but unsolved need, failure of others, etc., [that] might be utilized to give light to the circumstances surrounding the origin of the subject matter sought to be patented.” *Id.* at 17-18.

22. *See MERGES, supra* note 20, at 479.

23. I am indebted to Ian Ayres for this idea.

mates that its rival is about to attain the requisite 10-increment standard, it can publish some information that improves the state of the art by 1 innovation increment, thereby spoiling its rival's plan to obtain a patent. Of course, nonobviousness is difficult to quantify in the real world, but the more general point remains valid: preemptive publication enables firms to play the role of the spoiler by raising the patentability bar.

To be sure, not every reference to an invention in a written publication will render the invention unpatentable.<sup>24</sup> Only a reference that contains an enabling disclosure of an invention negates patentability. Technically, this has been accomplished by the importation of the enablement requirement of § 112 into the novelty standard of § 102.<sup>25</sup> Under § 112, a publication is considered enabling if it discloses sufficient information to allow a person skilled in the art to produce the invention.<sup>26</sup> Thus, to constitute a bar to patentability, a reference must describe an invention in sufficient detail and accuracy; a merely suggestive reference will not do.

While the requirement of enabling disclosure restricts to some extent the ability of firms to preemptively publish their research results, it by no means eliminates it. The publishing firm enjoys four advantages over the patenting firm. First, any publication sufficiently accessible to the public interested in the art qualifies as a prior art reference.<sup>27</sup> A publication need neither pass exacting peer review nor be published in a prominent scientific or technological journal; even a publication in the firm's own journal will suffice if the public may access it.<sup>28</sup> Second, and relatedly, publications are not subject to strict

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24. Adopting such a rule would dramatically undermine the incentive to engage in R&D and, thus, would diminish social welfare.

25. See 35 U.S.C. § 112 (1994).

26. See, e.g., *Seymour v. Osborne*, 78 U.S. (11 Wall.) 516, 555 (1870) (holding that in order to constitute an anticipatory reference, a publication must "contain and exhibit a substantial representation of the patented improvement, in such full, clear, and exact terms as to enable any person skilled in the art or science to which it appertains, to make, construct, and practice the invention"); see also *Paperless Accounting, Inc. v. Bay Area Rapid Transit Sys.*, 804 F.2d 659, 665 (Fed. Cir. 1986) ("[E]ven if the claimed invention is disclosed in a printed publication, that disclosure will not suffice as prior art if it was not enabling."); ARTHUR R. MILLER & MICHAEL H. DAVIS, *INTELLECTUAL PROPERTY: PATENTS, TRADEMARKS, AND COPYRIGHT IN A NUTSHELL* 46, 47 (1983).

27. See *Constant v. Advanced Micro-Devices, Inc.*, 848 F.2d 1560, 1566-69 (Fed. Cir. 1988) ("If accessibility is proved, there is no requirement to show that particular members of the public actually received the information.").

28. See, for example, *In re Hall*, 781 F.2d 897, 899 (Fed. Cir. 1986), in which the Federal Circuit stated that public accessibility is the "touchstone in determining whether a reference constitutes a 'printed publication.'" A review of the case law reveals that indexing is the key factor in determining public accessibility. For example, in *In re Hall*, the court held that a doctoral dissertation that had been deposited and indexed in a German library was sufficiently accessible to constitute a printed publication. See *id.* at 899-900. By contrast, in *In re Bayer*, 568 F.2d 1357 (C.C.P.A. 1978), it was held that a thesis that had been catalogued but not indexed could not serve as a prior art reference.

examination of the Patent Office and thus need not be as accurate and specific as patent applications. Consequently, the publishing firm may, in principle, offer several ways to produce an invention, thereby increasing the probability of preemption. Third, even a publication that does not, on its own, trivialize an invention may still make it unpatentable in combination with other prior art references.<sup>29</sup> Thus, all a publication need to do is contribute the “marginal obviousness increment” to the prior art in order to block a patent. Finally, and perhaps most importantly, the publishing firm is favored by the “hindsight bias.”

The hindsight bias is a cognitive effect that causes people to “exaggerate what could have been anticipated in foresight . . . [and] to view [what has happened] as having appeared ‘relatively inevitable’ before it happened.”<sup>30</sup> Significantly, empirical studies in cognitive psychology have repeatedly demonstrated that as a consequence of the hindsight bias, we tend to overestimate, *ex post*, the *ex ante* predictability of events that actually occurred.<sup>31</sup> Although no empirical tests have been

29. The permissibility of combining references is what distinguishes the obviousness inquiry from the novelty inquiry. As Judge Lourie explicated in *Pro-Mold & Tool Co. v. Great Lakes Plastics, Inc.*, 75 F.3d 1568 (Fed. Cir. 1996):

If one prior art reference describes the claimed invention, it is worse than obvious in terms of patentability; it lacks novelty. If the invention is different from what is disclosed in one reference, but the differences are such that combination with another reference would lead to what is claimed, the obviousness question then requires inquiry into whether there is reason, suggestion, or motivation [in the prior art] to make that combination.

*Id.* at 1573. Thus, courts will not automatically combine prior art references when making an obviousness determination, but rather look to other factors existent at the time. Such a suggestion may be explicit, *see, e.g., In re Sernaker*, 702 F.2d 989, 994 (Fed. Cir. 1983), or implicit, *see, e.g., In re Nilssen*, 851 F.2d 1401, 1403 (Fed. Cir. 1988), in the prior art literature. It may also derive from the knowledge of those skilled in the relevant art, *see, e.g., Ashland Oil, Inc. v. Delta Resins & Refractories, Inc.*, 776 F.2d 281, 297 n.24 (Fed. Cir. 1985), or from the nature of the problem to be solved, *see, e.g., In re Rinehart*, 531 F.2d 1048, 1054 (C.C.P.A. 1976).

30. Baruch Fischhoff, *For Those Condemned to Study the Past: Heuristics and Biases in Hindsight*, in *JUDGMENT UNDER UNCERTAINTY: HEURISTICS AND BIASES* 335, 341 (Daniel Kahneman et al. eds., 1982).

31. *See, e.g.,* Baruch Fischhoff, *Hindsight [not =] Foresight: The Effect of Outcome Knowledge on Judgment Under Uncertainty*, 1 *J. EXP. PSYCHOL.* 288 (1975) (first to identify the hindsight bias); *see also* Jay J.J. Christensen-Szalanski & Cynthia Fobian Willham, *The Hindsight Bias: A Meta-analysis*, 48 *ORGANIZATIONAL BEHAV. & HUM. DECISION PROCESSES* 147, 147-48 (1991); Scott A. Hawkins & Reid Hastie, *Hindsight: Biased Judgments of Past Events After the Outcomes Are Known*, 107 *PSYCHOL. BULL.* 311, 312 (1990); Kim A. Kamin & Jeffrey J. Rachlinski, *Ex Post ≠ Ex Ante*, 19 *LAW & HUM. BEHAV.* 89 (1995); Susan J. LaBine & Gary LaBine, *Determinations of Negligence and the Hindsight Bias*, 20 *LAW & HUM. BEHAV.* 501 (1996). For possible ways to eliminate the hindsight bias in legal, and other settings, *see, for example,* Hal R. Arkes et al., *Eliminating the Hindsight Bias*, 73 *J. APPLIED PSYCHOL.* 305, 306 (1988); Christine Jolls et al., *A Behavioral Approach to Law and Economics*, 50 *STAN. L. REV.* 1471, 1523-33 (1998); Jeffrey J. Rachlinski, *A Positive Psychological Theory of Judging in Hindsight*, 65 *U. CHI. L. REV.* 571, 615 (1998); David B. Wexler & Robert F. Schopp, *How and When to Correct for Juror Hindsight Bias in Mental Health Malpractice Litigation: Some Preliminary Observations*, 7 *BEHAV. SCI. & L.* 485, 496 (1989).

conducted to evaluate the influence of the hindsight bias on nonobviousness determinations,<sup>32</sup> its applicability to such determinations is indisputable. Indeed, the case law on nonobviousness reveals that courts have been especially conscious of not falling prey to the hindsight bias,<sup>33</sup> even looking to objective criteria — such as the commercial success of the invention — in an attempt to avoid it.<sup>34</sup> Yet, there is no proof that the courts' cautionary approach has helped in overcoming the hindsight bias. Between 1982 and 1994, the Federal Circuit invalidated approximately 30% of the patents litigated before it for lack of novelty or obviousness, even though they had been approved by the Patent Office.<sup>35</sup> Furthermore, several leading commentators have observed that the correlation between the secondary considerations used by the courts and the nonobviousness of inventions may often be quite tenuous.<sup>36</sup> Thus, it seems, at the end of the day, that the hindsight bias still gives potential "publishers" an important advantage over potential patentees.

## II. PATENT RACES WITH PREEMPTIVE PUBLICATION

This Part demonstrates that preemptive publication may dominate the strategy of pursuing a patent in *all* race settings. Broadly speaking, there can be two types of race settings: symmetric races and asymmetric races. A race is symmetric when the two competing firms are identical in their research capabilities, financing capabilities, and timing decisions. A race is asymmetric when one of the competing firms has

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32. See Rachlinski, *supra* note 31, at 614.

33. See, e.g., *Grain Processing Corp. v. American Maize-Prod. Co.*, 840 F.2d 902, 907 (Fed. Cir. 1988) ("Care must be taken to avoid hindsight reconstruction . . ."); *Panduit Corp. v. Dennison Mfg. Co.*, 774 F.2d 1082, 1091 (Fed. Cir. 1985) ("It is not appropriate for the Court to engage in hindsight."); *W.L. Gore & Assoc. v. Garlock, Inc.*, 721 F.2d 1540, 1553 (Fed. Cir. 1983) ("It is difficult but necessary that the decisionmaker forget what he or she has been taught at trial about the claimed invention and cast the mind back to the time the invention was made . . .").

34. For example, Rachlinski notes that the Supreme Court's invocation of "secondary considerations" in *Graham v. John Deere Co.*, 383 U.S. 1, 17 (1966), stemmed, at least in part, from the Court's desire to neutralize the hindsight bias. See Rachlinski, *supra* note 31, at 614.

35. See Donald R. Dunner et al., *A Statistical Look at the Federal Circuit's Patent Decisions: 1982-1994*, 5 FED. CIRCUIT B.J. 151, 163-68 (1995). Historically, the invalidation rate was even higher. For example, between 1921 and 1973, district courts invalidated 55% of the patents challenged, and the courts of appeals invalidated 65%. See A. Samuel Oddi, *Beyond Obviousness: Invention Protection in the Twenty-First Century*, 38 AM. U. L. REV. 1097, 1140 n.241 (1989).

36. In fact, several leading commentators have questioned the wisdom of reliance on secondary considerations in determining nonobviousness. See, e.g., Robert P. Merges, *Commercial Success and Patent Standards: Economic Perspectives on Innovation*, 76 CAL. L. REV. 803, 823-24 (1988) (noting that commercial success is not a reliable test of the nonobviousness of the invention). Factors such as commercial success and other secondary considerations may often be poor indications of the obviousness of an invention.

an advantage over the other, perhaps because it has superior human resources, it invests more in R&D, or it started research earlier.

In order to analyze the effects of preemptive publication on symmetric and asymmetric public races, I will construct, in the following Sections, a game theoretic model of a patent race. Through the model, I will compare conventional theorizing of patent races — one that ignores preemptive publication — with one that takes preemptive publication into account.

### A. Model of a Symmetric Race

To illustrate the impact of preemptive publication on patent races, it is helpful to think of a simple inventive setting in which two firms compete for a patent. For example, one can imagine two new pharmaceutical firms, A and B, engaged in a competition for a new drug. To conduct research for the new drug, each firm must invest \$1 initially, and then, depending on the outcome of the first stage of research, it may choose to invest another \$1 to conduct additional research. After two stages of research, each firm has to choose among three options: file for a patent, publish its research results, or do nothing (namely, keep its results secret), with the decision depending on the research results each firm ultimately obtains. Assume that if one of the firms receives a patent, it will obtain sole possession of the market and will make a monopoly profit of \$20. The other firm, in this case, will earn no profit, as the patent will legally bar it from producing the drug. Thus, the payoff to the patenting firm is \$20, and the payoff to the loser is \$0.

Assume further that if either firm can bar its rival from obtaining a patent by publishing its research results, the two firms will divide the market evenly with each of them making a duopoly profit of \$8.<sup>37</sup> Thus, the symmetric payoff in the case of publication is \$8.<sup>38</sup> The assumption here is that by removing the legal barrier of the patent, the publishing firm will be able, at a later stage, to manufacture the new drug, which, in turn, will enable it to share the market with the other firm and earn a positive profit.<sup>39</sup> The model also accounts for the pos-

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37. This assumption that a monopoly profit is higher than twice the duopoly profit is consistent both with the Bertrand model and the Cournot model of duopoly (assuming linear demand curve and constant marginal cost). In reality, the payoff of the competing firms from publication may be much lower than the duopoly profit. Publication enables all comers to use the information published and thus benefits all firms currently on the market as well as potential entrants.

38. As explained below, I assume that a firm will choose to publish only if its rival will otherwise receive a patent. In other words, a firm will publish only if by so doing it will spoil a patent to its rival. If neither firm obtained sufficient research results to file for a patent, neither will publish. See *infra* note 42 and accompanying text.

39. In reality, the firm that was on the verge of patenting will have an advantage over its rival because it will have the advantage of being first on the market. Thus, the payoffs of the

sibility that neither firm yields sufficient research results to produce the new drug — namely, the possibility of a failed attempt — in which case each firm will earn a payoff of \$0 and lose its investment in R&D (either \$1 or \$2).

I will represent the race for the new drug as a simple, highly stylized, die-game between the two competing firms. Because luck plays such an important role in the inventive process, it is useful to analogize patent races to die-games. Imagine that instead of conducting research, the two competing firms engage in a die-game in which a \$1 investment (representing the investment in R&D) buys them one roll of a special die with the number 1 on three of its faces, and the number 4 on the remaining three. Thus, every roll yields a 0.5 probability of getting a 1, and a 0.5 probability of getting a 4. Assume that the numbers 1 and 4 represent innovation increments. Accordingly, a roll of 4 enables a firm to improve on the prior art by four innovation increments, and a roll of 1 by one innovation increment. To obtain a patentable result — a result that is both novel and nonobvious — under this game, a firm needs to attain a total of at least 6 innovation increments.<sup>40</sup> Any lesser result (a total of 2 or 5) will fail to satisfy the obviousness standard.

Finally, assume that the game proceeds in two rounds of four stages. At stage I, each firm must decide whether to invest \$1 to earn the right to roll. At stage II, each firm that decided to invest gets to roll the die. At stage III, each firm learns of the other firm's result. Finally, at stage IV, each firm decides whether to "move" — patent, publish, or do nothing — or play another round for an additional cost of \$1.

I will analyze the probable outcomes of the game under two legal regimes: a regime that ignores the possibility of publication, and a regime that takes publication into account. Under the first regime, which prohibits preemptive publication, a patent will issue any time one or more firms attain a total of 6 or more,<sup>41</sup> and nothing will happen otherwise. Under the second regime, a patent will issue only when either firm attains a total of at least 6 and the other firm cannot block the patent by publishing its results (namely, when one firm attains 8 and the other has 2 or less); or when both attain a total of 6 or more. Under this regime, a firm will elect to publish whenever doing

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firms may in many cases not be identical. This, however, does not affect the generality of the results of the model, since the main point here is that publication may yield a positive payoff to the firm trailing in the race.

40. Or, more precisely, to patent under this game, a firm needs a 4 on both rolls (a total of 8).

41. If both firms attained a total of 8 they will divide the patent evenly between them. Or, put differently, each firm will get the whole of the patent with equal probability. For instance, they may flip a coin, or even roll a die, to decide which firm will receive the patent. Thus, they will each earn a profit of \$10.

so spoils a patent for its rival — namely, when publication will prevent the rival from attaining the necessary six increment margin over the prior art. If a firm can neither patent nor block the issuance of a patent to its rival, it will choose to do nothing.<sup>42</sup> The equilibria of the game under a “no-publication regime” are listed in Table 1, and the equilibria of the game under a regime with publication are listed in Table 2.

TABLE 1: SYMMETRIC GAME WITHOUT PREEMPTIVE PUBLICATION<sup>43</sup>

Probability that a patent will issue	0.4375
Probability that neither will obtain a patent	0.5625
Average total (both firms) R&D expenditure	\$3.000
Average expected payoff for each firm	\$2.875

TABLE 2: SYMMETRIC GAME WITH PREEMPTIVE PUBLICATION<sup>44</sup>

Probability that a patent will issue	0.1875
Probability of preemptive publication	0.2500
Probability of neither a patent nor publication	0.5625
Average total (both firms) R&D expenditure	\$3.500
Average expected payoff for each firm	\$2.125

A comparison of the two games reveals several important results. First, the introduction of the option of preemptive publication did not result in a decrease in R&D activity. On the contrary, the introduction of preemptive publication led to a higher total investment in R&D (\$3.5 versus \$3). Preemptive publication makes this possible

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42. Thus, in a race without publication, a firm that rolls a 1 on its first turn will drop out after spending \$1 on R&D because it cannot possibly obtain a patent. (“Doing nothing” also enables a firm to maintain trade secrecy protection.) In a race with publication, however, a firm rolling a 1 on its first turn will still have an incentive to remain in the race if its opponent has rolled a 4. The firm will spend the extra \$1 to try and preempt its rival, thereby earning a possible stake in the market.

43. Of the 7/16 possible permutations in which either firm rolls an 8, each firm obtains the patent 3 times outright, whereas they will split the single remaining possibility. Furthermore, because a firm has a 0.5 chance of rolling a 1 on its first turn, each firm will spend an average of \$1.50 on R&D. Therefore, the average expected payoff is:  $[(-\$1.50) + (3/16)(\$20) + (1/16)(\$10)] = \$2.875$ .

44. With preemptive publication, the rival firm will preemptively publish, thus thwarting 4 of the 7 chances to obtain a patent; therefore, each firm has a 1/16 chance of winning the patent outright, and a 1/16 chance of splitting the patent. Because a firm rolling a 1 will spend an extra \$1 whenever its rival rolls a 4, each firm will spend an average of \$1.75 on R&D. Therefore, the average expected payoff for each firm is:  $[(-\$1.75) + (4/16)(\$8) + (1/16)(\$20) + (1/16)(\$10)] = \$2.125$ .

because the firm that initially obtained poor research results has an incentive to carry on with the research in the hope of spoiling a patent for its rival by obtaining publishable results at some later stage. As the model illustrates, in a game without publication, the dominant strategy for a firm getting a 1 on the first roll is to quit after this round. Not so in a game that allows for publication since a roll of 4 gives it a positive payoff.<sup>45</sup> Consequently, the availability of preemptive publication in this setting produces additional investment originating with the trailing firm; thus, when preemptive publication is allowed, we should expect a higher level of expenditure on R&D from firms that would otherwise quit the race.

Second, under both regimes new information is disclosed to the public 43.75% of the time. This implies that the introduction of preemptive publication does not necessarily diminish the amount of information made available to the public. Yet, while under the first regime information is always disclosed with the societal deadweight cost resulting from patent protection, the second regime imposes a deadweight loss only 18.75% of the time, while disclosing information 25% of the time at no societal cost. Furthermore, when the disclosure results from publication rather than from patent protection, the information may be used costlessly by other firms for their respective research projects. Hence, preemptive publication reduces the cost of information to society and other firms.

Preemptive publication also has the salutary effect of shifting the timing of disclosure. As explained earlier, the stage at which a firm may publish always precedes the stage at which it may file for a patent. Publication becomes possible when a firm possesses sufficient theoretical knowledge to enable an invention. Patenting requires reduction of this knowledge to practice. In addition, a firm choosing to patent must also satisfy the necessary legal requirements for obtaining a patent. Hence, even from the inventor's point of view, there is a time lag between the publication stage and the patenting stage. From a societal standpoint, however, the lag is much greater. The information contained in a patent application becomes available to the public only after the Patent Office examines the patent and approves it. The examination takes 18 months, on average, and is conducted under absolute secrecy.<sup>46</sup> As a result, information in publications reaches the market considerably earlier than does information in patent applica-

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45. Of course, in reality the decision of how much R&D to conduct ultimately depends on the value of the patent. Still, in a "winner take all" game, a firm that fell behind in the early stages of research may rationally decide to drop out of the race since its probability of ultimately beating its rivals may not justify the additional investment in R&D. Formally this happens when  $X > P(Pt)$ .

46. See Scott Erickson, *Patent Law and New Product Development: Does Priority Claim Basis Make a Difference?*, 36 AM. BUS. L.J. 327, 336 (1999) (noting that the average processing time of a patent application in the United States is eighteen months).



tions.<sup>47</sup> The sooner new information becomes public, the sooner it may be put to valuable uses, and, consequently, the more socially valuable it is.

Finally, it should be noted that the possibility of preemptive publication reduces the average expected payoff of the firms in the race (from \$2.875 to \$2.125). This indicates that the introduction of preemptive publication may erode the incentive to engage in patent races, and more generally in R&D. Thus, at the margin, the possibility of preemptive publication may deter firms from initiating certain research projects, and thus adversely affect innovation.

### B. *Model of an Asymmetric Race*

To make the game more closely resemble commercial reality, I will assume in this Section that the firms in the race diverge in their likelihoods of obtaining the patent. The difference may be due to superior human resources, higher investment in R&D, or an earlier start on the research. Each gives a firm an advantage over its opponents, increasing its chance of winning the race. To incorporate the divergence between the firms into the model, I will assume in this Section that firm B — the better endowed firm — rolls a loaded die with a 0.67 probability of yielding 4 and 0.33 probability of yielding 1,<sup>48</sup> while firm A rolls a die yielding 1 and 4 with equal probability. The higher probability of drawing a 4 — that is, of reaching a patentable result — is the only difference between the games; the payoffs of the players, the play order, and the decision menu remain the same. Once again, I will solve the game under two legal regimes, one that does not take publication into account and one that does. The equilibria of the game without publication are listed in Table 3, and the equilibria of the game with publication are listed in Table 4.

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47. See Rebecca S. Eisenberg, *Proprietary Rights and the Norms of Science in Biotechnology Research*, 97 *YALE L.J.* 177, 207 (1987) ("Patent disclosure is unlikely to occur until after a patent issues, which is often years later than disclosure to the scientific community would otherwise occur." (citation omitted)).

48. This will happen when the number 4 appears on four of the faces of the die, and the number 1 only on two.

TABLE 3: ASYMMETRIC GAME WITHOUT  
PREEMPTIVE PUBLICATION<sup>49</sup>

Probability that a patent will issue	0.5833
Probability that neither will obtain a patent	0.4167
Average total (both firms) R&D expenditure	\$3.167
Average expected payoff A, B	\$2.389, \$6.108

TABLE 4: ASYMMETRIC GAME WITH PREEMPTIVE PUBLICATION<sup>50</sup>

Probability that a patent will issue	0.2500
Probability that neither will obtain a patent	0.3333
Probability of neither a patent nor publication	0.4167
Average total (both firms) R&D expenditure	\$3.667
Average expected payoff A, B	\$2.500, \$4.164

Analyzing the equilibria of the game reveals that the introduction of asymmetry impacts the race in two ways. First, it slightly increases the publication-to-patenting ratio relative to the symmetric game. Such an increase should be expected whenever the firm leading the race is likely to receive the patent. The more likely the leading firm will obtain a patent, the more valuable becomes the strategy of preemptive publication to the trailing firm. Since spoiling a patent to a rival is both easier and less expensive than beating the rival to the patent, the firm trailing in the race will focus its efforts on obtaining publishable results to block a patent for the other firm.

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49. A patent will issue in 21/36 possible two roll permutations (given the weighted die) — 12 times to firm B, 5 times to firm A, and 4 times it will be split. Because firm B has a 2/3 chance of rolling a 4, it will spend the full \$2 two-thirds of the time. Thus, unlike firm A which will maintain the \$1.500 expenditure, firm B will spend an average of \$1.667. The total expected payoff for firm A will be:  $[(-\$1.50) + (5/36)(\$20) + (4/36)(\$10)] = \$2.389$ . The total expected payoff for firm B will be:  $[(-\$1.67) + (12/36)(\$20) + (4/36)(\$10)] = \$6.108$ .

50. Firm A will be able to preempt 2/3 of B's patents, thus giving B a patent only 6/36 times, while forcing a duopoly profit 8/36 times. Firm B, on the other hand, will be able to preempt 4/5 of A's patents, leaving A with a patent 1/36 times, while forcing a duopoly profit 4/36 times. Furthermore, both A and B will spend the same amount on R&D, choosing to pay the extra dollar 5/6 of the time. Thus, each spends an average of \$1.833 on R&D. As compared with the asymmetric race without publication, firm B loses  $[(8/36)(\$12) + (\$1.833 - \$1.667)] = \$2.833$ , while it gains  $(4/36)(\$8) = \$0.889$  from preempting firm A. Thus, its total expected payoff is:  $[\$6.108 + \$0.889 - \$2.833] = \$4.164$ . Firm A, however, loses only  $[(4/36)(\$12) + (\$1.833 - \$1.500)] = \$1.667$ , but gains  $(8/36)(\$8) = \$1.778$ . Thus, its total expected payoff is:  $[\$2.389 + \$1.778 - \$1.667] = \$2.500$ .

Second, a comparison of the expected average payoffs of the firms shows that the introduction of publication reduces the average payoff of the superior firm, far more than it does the payoff of the inferior firm. In fact, in the above scenario, firm B suffered over a 30% drop in its average expected payoff, whereas firm A enjoyed an almost 5% gain.<sup>51</sup> This result confirms the intuition that preemptive publication advantages the firm trailing in the race. The firm leading the race will choose, in most cases, the option of patenting — particularly if it employs superior researchers and faces no financing constraints. For such a firm, publishing is self-defeating. For the trailing firm, on the other hand, publication is often the profit-maximizing strategy.

The disparate impact of preemptive publication on the average expected payoffs of the firms has both distributive and efficiency implications. From a distributive standpoint, the availability of preemptive publication transforms patent races from a “winner take all” to a “multiple winner” race, making patent races more egalitarian than commonly believed. From an efficiency perspective, the exact effect depends on the potential race participants’ attitude towards risk. If inventors are risk averse, they will be more willing to participate in patent races. If, on the other hand, they are risk seeking, they will have less motivation to join.<sup>52</sup> Finally, if the firms are risk neutral, they will simply respond to the decline in average expected payoffs by lowering their investment in R&D. (Of course, all three kinds of companies would lower their R&D investment. Their relative dispositions therefore determine “by how much?”.) Yet, the reduction made by each of the firms will be different.

The sharper decline in the expected average payoff of the leading firm suggests that when publication is available, the firms most likely to win the race will invest substantially less in R&D than under a no-publication regime. It is impossible, however, to infer in the abstract how this reduction will actually affect social welfare; it is impossible to know whether the advantage of the leading firm is attributable to its superior research ability, better financing, initial headstart, or simply luck. The exact impact of preemptive publication on efficiency ultimately turns on the circumstances of each inventive race and the characteristics of the competing firms. All that can be predicted is that in the very rare case in which all firms start the race at the same time, the possibility of preemptive publication will tend to favor smaller, lesser-endowed firms relative to their larger, better-endowed competitors.<sup>53</sup>

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51. Whether and how much of an increase the inferior firm will realize with the possibility of preemptive publication depends on the relative advantage of the superior firm.

52. For an argument that participants in patent races are risk seeking, see John S. McGee, *Patent Exploitation: Some Economic and Legal Problems*, 9 *J L & ECON.* 135, 136 (1966).

53. However, even in this case, the smaller firm may serendipitously get to the invention first.

### III. PREEMPTIVE PUBLICATION AND SOCIAL WELFARE

In analyzing the welfare effects of preemptive publication, I will proceed under two alternative assumptions. First, I will assume that no bargaining between the competing firms is possible, and thus the firm trailing in the race will always publish the information it possesses when doing so spoils a patent for the other firm. Then, I will reverse the initial assumption to enable bargaining between the firms prior to the act of publication.

#### A. *No Bargaining Regime*

Recognizing the availability of preemptive publication reveals several implications for our understanding of the welfare effects of the patent system. The realization that in many cases utility-maximizing firms, acting in their own self-interest, may choose to make valuable information available to the public even without receiving a patent challenges the conventional assumption that the patent system induces disclosure of information solely through a limited monopoly reward. As this Article demonstrates, the threat of not being rewarded — namely, not receiving a patent — may be as effective an inducement to disclose information as the prospect of reward. In the former case, the disclosure occurs through a regular publication, in the latter, through the patent grant. It bears emphasis, though, that the two means of disclosure have different efficiency effects.

Publication avoids the societal deadweight loss generated by patents since it makes the information available at no direct cost. Significantly, it circumvents the troublesome tradeoff underlying patent law: new information in exchange for limited monopoly power. Furthermore, disclosure by publication allows third parties to exploit the new information considerably earlier than they could in the case of disclosure by patent. Also, the absence of patent protection obviates the need to bargain for the right to use the information, and thus reduces transaction costs. Yet, the effect of preemptive publication on societal welfare is not strictly positive. The availability of preemptive publication reduces the expected average payoffs of the race participants and may consequently diminish, in some cases, the *ex ante* incentive to engage in R&D.<sup>54</sup> In addition, the possibility of preemptive publication forces race participants to expend resources on monitoring the progress of other competitors. Rather than focusing all research efforts on developing the invention, firms will have to divide those efforts between conducting their own research and monitoring competitors' research activities. Although such monitoring is not entirely wasteful, it

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54. The exact impact of preemptive publication depends on the competing firms' attitudes towards risk.

is an additional cost that will slow down the development of new products and processes. Thus, preemptive publication represents a tradeoff between *ex ante* and *ex post* efficiency, a tradeoff that has become the hallmark of intellectual property law.

Notwithstanding this tradeoff, preemptive publication is likely to promote societal welfare in at least two inventive settings. First, the strategy of preemptive publication offers strong benefits in research areas whose development depends on uninhibited access to basic research. Biotechnology provides an example<sup>55</sup> — publication of research findings ensures access to basic research results and thus mitigates the threat of overappropriation of essential knowledge.<sup>56</sup> A similar effect may be expected in other fields as well. Because patent races will more likely occur with respect to socially important inventions, recourse to preemptive publication may block the appropriation of fundamental developments and force firms to compete for variants of such inventions, or, as they are called in the patent vernacular, improvements.

Second, and relatedly, preemptive publication should be particularly desirable when network effects are present. Network effects exist in a market when the value of the good traded increases with the number of users.<sup>57</sup> The paradigmatic examples of network goods are communication goods, such as telephones, fax machines, and even personal computers. The realization of network externalities depends on the establishment of compatible technologies. Without such a standard, potential networks will not come to pass. For instance, if Internet Service Providers used different, incompatible technological standards, the Internet, as we know it, would not exist. Patents pose an obvious threat to network markets. The appropriation of a certain technology by one firm will often force other firms to develop other, incompatible technologies in order to circumvent the patent.<sup>58</sup> In the process, potential positive network effects will be lost. Preemptive publication can alleviate some of this problem. Specifically, preemptive

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55. See, e.g., Michael A. Heller & Rebecca S. Eisenberg, *Can Patents Deter Innovation? The Anticommons in Biomedical Research*, 280 *SCIENCE* 698 (1998) (arguing that the recent proliferation of fragmented intellectual property rights may result in a biomedical anticommons, which will lead, in turn, to underuse of resources and knowledge).

56. In fact, the field of biotechnology developed around two basic discoveries for which no patent protection was claimed. The first was Köhler and Milstein's discovery of a technique of producing antibodies. The second was Cohen and Boyer's discovery of a technique for expression of recombinant proteins. See Robert P. Merges & Richard R. Nelson, *On the Complex Economics of Patent Scope*, 90 *COLUM. L. REV.* 839, 905-06 (1990).

57. See Michael L. Katz & Carl Shapiro, *Network Externalities, Competition, and Compatibility*, 75 *AM. ECON. REV.* 424, 424 (1985). For a comprehensive analysis of the potential implications of network externalities to various legal fields, see Mark A. Lemley & David McGowan, *Legal Implications of Network Economic Effects*, 86 *CAL. L. REV.* 479 (1998).

58. On the relationship between networks and innovation, see Joseph Farrell & Gather Saloner, *Standardization, Compatibility and Innovation*, 16 *RAND J. ECON.* 70 (1985).

tive publication may be used to safeguard against the appropriation of basic technological standards and thus facilitate the creation of technological networks.

Furthermore, the availability of preemptive publication also bears directly on the question of optimizing R&D investment. Several leading economists have criticized the patent system for inducing overinvestment in R&D.<sup>59</sup> However, the criticism relies on the conventional assumption that firms in a patent race face only the risk of being beaten to the patent (Type I risk). In reality, firms also face the risk of preemptive publication (Type II risk). By ignoring the possibility of preemptive publication, conventional theorizing has underestimated the actual risk involved in patent races and, as a result, may have overstated the overinvestment problem.<sup>60</sup>

Although one might intuit that the availability of preemptive publication would mitigate the overinvestment problem, the exact effect of preemptive publication on R&D investment is indeterminable in the abstract. The possibility of preemptive publication is at once a risk and an opportunity, depending on the firm's position in the race. For the firm likely to win the race, preemptive publication represents a risk; for the other firms, it is an opportunity. In perfectly symmetric races, where luck determines the winner and the loser, the opposing effects of preemptive publication offset one another.<sup>61</sup> Yet, because the availability of preemptive publication reduces the average expected payoffs, both the winner and the loser should invest less in R&D than they would otherwise.

In asymmetric races the situation is different. In such races, the strategy of preemptive publication presents trailing firms with a unique opportunity to remain competitive without winning the patent. The availability of preemptive publication may induce firms that would otherwise drop out of the race to remain in it; worse, it may attract to patent races firms that otherwise would not have entered them at all. Whereas from the point of view of each individual firm, joining the race might be a profit-enhancing strategy, it is clearly wasteful in the aggregate, since it leads to duplicative research expenditures. This

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59. See, e.g., Yoram Barzel, *Optimal Timing of Inventions*, 50 REV. ECON. & STAT. 348 (1968); Dasgupta & Stiglitz, *supra* note 1, at 13-14; Jack Hirshleifer, *The Private and Social Value of Information and the Reward to Incentive Activity*, 61 AM. ECON. REV. 561, 571-72 (1971); Brian D. Wright, *The Economics of Invention Incentives: Patents, Prizes, and Research Contracts*, 73 AM. ECON. REV. 691, 703 (1983) (asserting that unlimited patents will lead to overinvestment in R&D).

60. Note, however, that this Article does not suggest that there is no overinvestment problem. That is a complex question that lies beyond the scope of this Article. I claim only that because of the risk of preemptive publication, the amount of overinvestment may be smaller than presently believed.

61. In such races, no firm can know *ex ante* whether it will be harmed or benefited by the availability of preemptive publication.

observation lends support to the criticism that the patent system leads to overinvestment in R&D. Importantly, however, it identifies a new source of overinvestment: the desire to preempt a rival.

But what about the leading firm? The leading firm's motivation in patent races is different from that of the others. Generally speaking, the leader's profit-maximizing strategy is to try and win; that of the other firms is simply not to lose. Hence, for the leading firm the possibility of preemptive publication offers a potential risk. The leading firm can respond to the risk of preemptive publication in one of two opposing ways. First, it may increase its investment in R&D in order to obtain the patent faster and thus minimize the risk of preemption. Second, it may lower its investment in R&D out of fear of being preempted. In the latter case, the availability of preemptive publication leads to a perverse result: it reduces the R&D investment of the firm most likely to win the race, while it increases the investment of other firms.<sup>62</sup> This result may explain the disparity between the private value and social value of certain inventions.<sup>63</sup>

The possibility of preemptive publication potentially transforms patent races from competitions for one large prize into competitions with multiple prizes. The exact number of "winners" ultimately depends on the respective research capabilities of the firms, the time at which they joined the race, and the "size" of the legal nonobviousness standard. The respective payoffs to the firms depend on both the value of the patent and the returns from preemptive publication. The availability of bargaining also bears on the payoffs of firms in patent races. It is to this factor that I now turn.

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62. This result is made possible by the imperfect information firms have about their potential competitors. Having insufficient information about its competitors, the leading firm may overestimate its own ability to beat its competitor to the patent, or merely to beat its competitor's publication. The strategy of increasing the investment runs the risk of being undercapitalized in future projects if the firm is ultimately unsuccessful in obtaining the patent.

However, it is important to note that the risk of preemptive publication is by no means the only reason for the observed disparity between the private and social value of certain inventions. Nor is it the most significant one. The main reason for this disparity is the imperfect enforceability of patents. Because patents are not perfectly enforceable, patents generate spillovers. While this result is desirable *ex post*, it undermines the *ex ante* incentive of inventors to invest in R&D and thus drives a wedge between the social value of the invention and its private value. Cf. Ian Ayres & Paul Klemperer, *Limiting Patentees' Market Power Without Reducing Innovation Incentives: The Perverse Benefits of Uncertainty and Non-Injunctive Remedies*, 97 MICH. L. REV. 985 (1999) (arguing that encouraging limited amounts of patent infringement while extending patent duration may "substantially reduce the distortionary *ex post* effects of supracompetitive pricing without reducing the patentee's *ex ante* incentives to innovate").

63. See, e.g., Timothy F. Bresnahan, *Measuring the Spillovers from Technical Advance: Mainframe Computers in Financial Services*, 76 AM. ECON. REV. 742, 753 (1986); Michael Kremer, *Patent Buyouts: A Mechanism for Encouraging Innovation*, 113 Q.J. ECON. 1137, 1141 (1998); Edwin Mansfield et al., *Social and Private Rates of Return from Industrial Innovations*, 91 Q.J. ECON. 221, 234 (1977).

### B. *Enter Bargaining*

The availability of bargaining introduces an important element into the analysis.<sup>64</sup> Rather than spoiling a patent to a rival by publishing its research results, the trailing firm can contact the leader and threaten to publish. Since such a threat may clearly be credible, the recipient will not be able simply to ignore it and will have to inquire into the nature of the threat. If the threat is credible, the intended patentee will have to “bribe” the other firm to prevent it from publishing. The two firms will then negotiate in order to strike a mutually beneficial deal. Assuming Coasean bargaining under conditions of equal bargaining power, the intended publisher and intended patentee will divide the contractual surplus evenly between them. Under the assumptions of the model in Section II.B, the amount of the “bribe” in such a case would be \$10.<sup>65</sup> While this side-payment is a pure lump-sum transfer that does not affect the marginal cost of producing the patented product, it does affect the average expected payoffs of the firms.

When the possibility of Coasean bargaining is introduced into the asymmetric race in Section II.B, the expected average payoff of the better-endowed firm — firm B in the model — is \$4.84, and that of firm A is \$3.17. As one would expect, the availability of bargaining increases the payoffs of the firms relative to a regime with publication but no bargaining — in which case, the expected payoffs of firms A and B are \$2.500 and \$4.165, respectively. Thus, the introduction of bargaining mitigates to some extent the effect of preemptive publication on the investment decisions of the firms.<sup>66</sup>

Bargaining may either occur *ex ante*, before research begins, or *ex post*, after the firms assume their respective positions in the race. The main advantage of *ex ante* bargaining is that it allows firms to consolidate otherwise duplicative research efforts. Rather than competing head-on against each other, risking the possibility of preemption, firms

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64. Again, the analysis in this Section does not address the various antitrust ramifications of coordinated R&D. Negotiations between firms to coordinate may violate the Sherman Act depending on the market power of the participants and the importance of the research. Yet, the exact antitrust implications of coordinated research cannot be determined in the abstract.

65. Under this model, payoffs in the case of a patent are \$20 to the patenting firm and \$0 to the other firm. The payoff in the case of publication is \$8 to each of the firms. Thus, under an assumption of equal bargaining powers, the intended patentees will have to pay the other firm  $8 + 0.5(12 - 8) = 10$ . Formally, the result of this bargaining game can be described as follows: Let  $\alpha$  denote bargaining power such that  $0 < \alpha < 1$ . For any  $\alpha$ , the amount of the side-payment would be  $8 + \alpha(4)$ . A necessary condition of bargaining in this case is that the payoff from publication be smaller than half the value of the patent.

66. Yet, even after the introduction of bargaining, the average expected payoffs of the firms are lower than what they would be without publication — in which case, the expected payoffs of firms A and B are \$2.388 and \$6.277, respectively.



may identify their strongest rivals in advance and try to cooperate with them. Such cooperation holds out several benefits for the firms and for society at large. From the firms' perspective, consolidation of research efforts increases the likelihood of success in R&D while lowering the cost of research.<sup>67</sup> Both effects are also desirable from a societal standpoint. Coordination of research efforts not only increases the likelihood of success, but also enhances the speed of research and the dissemination of information. The earlier a patent issues, the sooner society receives new information. Likewise, the cost reduction wrought by consolidated research economizes on valuable resources, freeing them for other desirable goals. Yet, the possibility of Coasean bargaining has its vices.

Coasean bargaining delays the disclosure of information to the public relative to a "no bargaining" regime, and when the information is finally disclosed, it happens at the cost of social deadweight loss associated with patent protection. Thus, Coasean bargaining effectively eliminates the potential *ex post* benefits of preemptive publication — under Coasean bargaining no publication would ever occur. Importantly, however, there are powerful reasons to believe that Coasean bargaining is not very likely in the present context.

For Coasean bargaining to occur, firms must possess perfect information about each other's research plans and accomplishments. Such perfect information, however, would only be available if research activity were completely transparent. This is far from the case in the real world. In fact, firms actively protect information about their R&D efforts, even taking special precautions to prevent inadvertent leaks. As Arrow demonstrated in explaining the need for patent protection, bargaining over unprotected information is very unlikely to occur.<sup>68</sup> The stakes involved are simply too high. Furthermore, in the absence of transparency, firms will often be unable to ascertain which publication threats are real and which are not. A firm that agreed to pay off one competitor may find itself inundated with threats from others, all requiring the same treatment.<sup>69</sup> Sifting out the real from the fake threats may often turn out to be impossible, and almost always

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67. Because *ex ante* contracting occurs before costs are sunk, it lowers the cost of achieving cooperation relative to *ex post* negotiations. It should be noted, however, that *ex ante* coordination may give rise to potential antitrust liability for the firms involved.

68. Specifically, Arrow identified the following problem: Without disclosing the information she obtains, the initial holder will not be able to sell or license it to potential buyers; but once the information has been disclosed, she has nothing left to sell or license. See Kenneth J. Arrow, *Economic Welfare and the Allocation of Resources for Invention*, in *THE RATE AND DIRECTION OF INVENTIVE ACTIVITY* 609, 615 (1962).

69. See Robert P. Merges, *Contracting into Liability Rules: Intellectual Property Rights and Collective Rights Organizations*, 84 *CAL. L. REV.* 1293, 1305-06 (1996) (demonstrating the inability of intellectual property owners to distinguish between credible and noncredible threats of infringements).

too time-consuming. Thus, it will likely be in the patenting firm's best interest not to bargain at all, even if doing so runs the risk of being preempted.

Advance coordination in the form of joint ventures avoids some of the pitfalls of *ex post* bargaining, but it too is not problem-free. Since collaborating with all potential preemptors is impracticable, each firm would have to choose its research partners carefully. However, identifying the right research partners is a tricky task, and the excluded firms may respond by forming rival coalitions to remain competitive. Thus, although coordination benefits society by reducing the number of duplicative research efforts, it does not necessarily eliminate the risk of preemptive publication. At the end of the day, bargaining and cooperation will not always assuage the risk of preemptive publication.

#### IV. THE DOUBLE PREEMPTION TWIST

In order to shelter itself from the risk of preemption, the intended patentee can employ the defense tactic of publishing its own research results and then filing for a patent within one year of the date of publication. Section 102(b) of the Patent Act grants a one-year grace period in which the publisher can file for a patent, thus effectively enabling the patentee to preempt the preemptor. The one-year grace period established by § 102(b) has traditionally been understood to encourage early disclosure of information by patent applicants.<sup>70</sup> Yet, the traditional rationale makes very little sense when the possibility of preemptive publication is ignored. Section 102(b) provides patent applicants with a very limited incentive to disclose earlier. Granted, early disclosure enables firms to gain a better estimate of the value of the invention prior to the patent's approval, to enter licensing agreements, and to satisfy the desire of researchers to publish as early as possible. Yet, absent a more substantial inducement, foregoing publication is actually the better option for patent applicants, since publication divests them of the natural protection of secrecy. Because inventors can never be certain of receiving the patent, their profit-maximizing strategy at this point is not to publish. Not only does early publication force them to file within one year, it also provides important information to rivals. Furthermore, because § 102(b) is uniquely American, early publication will hurt the publishing firms in foreign markets. Hence, when preemptive publication is ignored, § 102(b) seems puzzling.

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70. See, e.g., *General Elec. Co. v. United States*, 654 F.2d 55, 61 (Ct. Cl. 1981) (stating that one of the rationales for enacting the section is a "policy favoring prompt and widespread disclosure of new inventions to the public"); see also Patrick J. Barrett, Note, *New Guidelines for Applying the On Sale Bar to Patentability*, 24 STAN. L. REV. 730, 732-35 (1972).

The possibility of preemptive publication solves the puzzle by providing the inducement wanting in the traditional rationale. Faced with the possibility of being preempted, the intended patentee may find it in her best interest to publish first so as to neutralize the risk of publication by a rival. Publishing first eliminates the risk of preemption, but only at the cost of loss of secrecy. Consequently, in deciding whether or not to publish prior to filing, the intended patentee must evaluate the risk of preemption against the risk of failing to receive the patent,<sup>71</sup> and respond to the more imminent one. Patentees will, therefore, publish only if doing so is necessary to preempt publication by a rival.

An early publication by a patent applicant benefits society by moving forward the date of disclosure. In the absence of such a publication, the patentee will reveal the information to the public only when the patent issues, which in most cases will delay disclosure by approximately a year and a half.<sup>72</sup> The early disclosure, in the case of publication, enables other firms to put the information to new valuable uses sooner than they otherwise could and, in particular, to start developing improvements. Because in most cases the information disclosed by patent applicants will become protected by a patent less than a year after the date of publication, however, users will face the need to negotiate a mutually agreeable deal with the patent grantee. As a result, early publication by patent applicants does not provide free access to the information contained in the publication. Even so, earlier disclosure is welfare-enhancing as it accelerates the pace of innovation.

### CONCLUSION

The main goal of this Article has been to challenge the prevailing theory of patent races and its ability to aptly capture the inventive process. Standard theorizing models the inventive process as a race between two firms that results in one of *two* outcomes — neither firm reaches a patentable result, or one of the firms obtains the patent; no intermediate outcomes are considered. Yet, this analysis is flawed. While the firm ahead in the race will naturally do its best to obtain the patent and enjoy the legal monopoly that accompanies this achievement, the trailing firm will do whatever it can to prevent this from happening. To this end, the firm trailing in the race will utilize the

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71. A famous case that illustrates this point is *In re O'Farrel*, 853 F.2d 894 (Fed. Cir. 1988). In this case, two of the three patent applicants had reported their research findings in a scientific paper that came out more than a year before the filing date. In determining the validity of the patent, the Federal Circuit ruled that because the publication occurred more than a year prior to the date of filings, it rendered the invention obvious, and thus precluded the patent.

72. See Erickson, *supra* note 46.

only strategy the law makes available to it: it will publish its research findings in order to move the goalposts of nonobviousness for its rival. When this occurs, patent races may result in an equilibrium where no patent issues, but new information is disclosed.

The strategy of preemptive publication significantly alters existing understanding of patent races and their efficiency effects. The availability of preemptive publication transforms patent races from a "winner take all" to a "multiple winners" game. This transformation affects the risk involved in patent races, the investment decisions of the firms, and the cost of innovation to both the firms and the public at large. As is often the case with patents, the tradeoff between *ex ante* and *ex post* efficiency implicated by patent protection makes it difficult to determine in the abstract whether, on balance, the impact of the availability of preemptive publication on aggregate efficiency is positive or negative. Thus, a more thorough understanding of the welfare implications of preemptive publication requires empirical study. Yet, even the analysis presented in this Article has important normative implications for policymakers.

Determining the correct nonobviousness standard is the key to efficient innovation policy. A modest nonobviousness requirement would inefficiently reward infinitesimal innovation. A higher nonobviousness standard would appear to serve society better by filtering out relatively trivial inventions. Yet, as this Article shows, the possibility of preemptive publication changes the analysis. The higher the nonobviousness bar, the more likely preemptive publication will occur. Thus, courts must take into account the possibility of preemptive publication in determining the socially optimal nonobviousness standard. Naturally, legislation may enhance or diminish the possibility for preemptive publication. For instance, requiring that publication occur at least a year prior to the date of invention in order to preempt the patent would reduce the opportunity for preemptive publication. Conversely, allowing such publication to occur any time prior to the filing date would enhance instances of preemptive publication. Moreover, different rules may be devised for different industries, depending on the desirability of preemptive publication in each inventive setting.

While these determinations are of extreme importance to innovation policy, they lie outside of the purview of this Article. Yet, this Article's discussion of the various efficiency implications of preemptive publication should prove helpful to policymakers in making those determinations. If the analysis in this Article is correct, it shows that, at the end of the day, the realities of patent races and academic promotion are not so far apart.