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Damages and injunctions in protecting intellectual property

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We investigate how liability rules and property rules protect intellectual property. Infringement might not be deterred under any of the enforcement regimes available. However, counterintuitively, a credible threat of infringement can actually benefit the patentholder. We compare the two doctrines of damages, lost profit (lost royalty) and unjust enrichment, and argue that unjust enrichment protects the patentholder better than lost royalty in the case of proprietary research tools. Both can be superior to a property rule, depending on how much delay is permitted before infringement is enjoined. For other proprietary products (end-user products, cost-reducing innovations), these conclusions can be reversed.

1. Introduction

■ Rights to intellectual property are protected in two ways: by court orders to enjoin infringement, and by holding the infringer liable for damages. Injunctions intervene directly to stop infringement, whereas liability intervenes indirectly by making the infringement unprofitable. Under U.S. law, there are two liability doctrines that might determine damages. The first is that the infringer must reimburse the property owner's ''lost profits,'' and the second is that he must disgorge his ''unjust enrichment.'' We study the deterrence effects of damage rules and injunctions and their effect on a patentholder's profit.

Our main interest is in intellectual property that would normally be licensed, in particular, research tools. Examples include the Cohen-Boyer patent on the technology for inserting foreign genetic material into bacteria, the Genentech patent on a technology for getting foreign genes to ''express,'' the PCR technology for replicating DNA in test tubes, gene guns, and recent suppression technologies that cause gene sequences

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to become inactive. The salient feature of such property is that it is efficient to let firms other than the patentholder use it. It would thus normally be licensed, and the relevant notion of ''lost profit'' includes lost royalties.

Two of our main, and somewhat surprising, conclusions are that

(i) infringement is not necessarily deterred under either liability doctrine, and

(ii) the patentholder might *prefer* an enforcement regime that leads to infringement, absent a license.

Under the unjust-enrichment doctrine, an infringer must disgorge his ill-gotten gains, leaving him with zero profit. Whether such a rule would deter infringement depends on other aspects of the legal environment. If an infringer might escape liability entirely, e.g., by failure of the patentholder to detect infringement, then he might not be deterred from infringement under the doctrine. But if he would incur additional costs in litigation, such as lawyers' fees or punitive damages, he will more likely be deterred.

Deterrence can be even harder to ensure under the lost-profits doctrine. If the sole use of the intellectual property would be licensing, then the measure of ''lost profits'' is entirely lost royalties. The lost-profit (lost-royalty) doctrine leads to the following circularity: On one hand, prospective damages determine the maximum license fee that a licensee would pay. On the other hand, the presumed license fee determines the damages. License fees and prospective damages are equal and self-reinforcing.[1] We argue that many license fees and damages may be consistent with the doctrine, but the prospective damages will not deter infringement. License fees that more than exhaust the available profit could not arise in equilibrium and therefore could not be ''lost royalty.''

But, counterintuitively, a failure to deter infringement might benefit the patentholder. Consider a research tool whose sole profit will come from licensing. Ultimately, both the patentholder's and the licensee's (or infringer's) profit will come from selling a proprietary product that the tool will facilitate. If the enforcement regime deters infringement, it gives the potential licensee a credible threat not to develop the product, depriving both parties of profit. Hence, the licensee has a ''holdup'' threat for the value of the product, and this strengthens his bargaining position for a license. Compare this outcome with a damage regime that would not deter infringement. If infringement is a credible threat, the patentholder would not agree to license terms that give him less profit than he could get by refusing the license, letting the infringement go forward, and collecting damages *ex post.* If the expected damages are high enough (but not so high they deter infringement), these terms can be more attractive to the patentholder than those he would negotiate if the potential licensee could credibly threaten to deprive him of the product.

Injunctions are an alternative enforcement regime to liability. The patentholder can sue to enjoin an infringing use before an infringer has brought his new product to completion. However, deterrence by injunction can undermine profit in the same way as deterrence by the threat of high damages. Once an infringement is enjoined, the infringer has a credible threat not to develop the profitable product, and this gives him holdup power over the patentholder.

[1] Leitzel (1989) discusses a similar circularity for contract damages. He proposes to avoid circularity by defining ''reasonable'' damages as the socially efficient damages. This would not work in our context, where ''reasonable royalty'' is based on a hypothetical negotiation between the two parties in which the outcome may not be socially efficient. For a recent example in the context of copyright fair use, see *A.G.U.* v. *Texaco,* 60 F.3d 913 (2d Cir. 1994).

In studying these enforcement regimes, we take the view that infringement will never occur in equilibrium. If infringement is truly tempting, then the firms will license to avoid it, especially if the infringement would lead to inefficient use of the intellectual property. The only role of damages and injunctions is to set ''threat points'' for negotiating licenses. The terms of each license are negotiated in the shadow of what would happen otherwise, and in this way, the enforcement regime determines how profitable the patent is for its owner.

For most intellectual property, infringement of a patent reduces the patentholder's and infringer's joint profits, relative to licensing. For example, a cost-reducing innovation that is licensed with royalties will generate more profit to the patentholder and licensee jointly than if an infringer adopts the cost-reducing innovation without paying royalties. Competition without royalties will reduce the market price. In contrast, infringement of a research tool will not typically reduce the patentholder's and infringer's joint profit, even though it deprives the patentholder of his just reward. The profit arises from a proprietary product that is developed with the tool, and the profit available from that product does not typically depend on whether it accrues solely to an infringer, or whether part of the profit is paid back to the patentholder through license fees.

It turns out that this difference in profit dissipation matters for the relative attractiveness of the two damage rules. For research tools we conclude that

(i) a wide array of damage measures may be consistent with the lost profit (lost royalty) doctrine of damages, and infringement would not be deterred, absent a license.

(ii) damages under the unjust-enrichment doctrine are unique. If infringement would be deterred under that doctrine, then the two liability doctrines cannot be ranked. If infringement would not be deterred under the unjust-enrichment doctrine, that doctrine is generally more profitable to the patentholder than the lost-profit (lost-royalty) doctrine.

(iii) a right to enjoin infringement is more profitable to the patentholder than liability under the lost-royalty doctrine, even when both are available. However, injunctions are not an improvement if they must be invoked ''too soon'' or ''too late'' as governed by the *doctrine of laches*, discussed below.

These conclusions are in part reversed for other licensed intellectual property, such as product innovations or cost-reducing innovations, where infringement would lead to profit dissipation. For those we conclude that

(i) damages under both doctrines are unique. Infringement is unambiguously deterred under the lost-profit doctrine.

(ii) the lost-profit doctrine and unjust-enrichment doctrines are equally profitable to the patentholder if infringement is deterred under both doctrines, but otherwise unjust enrichment is less profitable to the patentholder.

In legal parlance, damages are awarded under a ''liability rule'' and injunctions are sought under a ''property rule.'' These rules have been discussed at length in the legal literature for other types of property. Calabresi and Melamed (1972) argued that a property rule is superior to a liability rule whenever transaction costs are low and information imperfect. This is because property rules induce bargaining, which will presumably lead to an efficient outcome. They argue that under a liability rule, the courts might not be able to assess appropriate damages or an efficient allocation. In a wide-ranging reassessment, Kaplow and Shavell (1996) disagreed with Calabresi and Melamed, pointing out that when transaction costs are low, the parties have incentives to bargain under *both* regimes. Our own analysis adopts the same point of view. Focusing on intellectual property, Blair and Cotter (1998) analyzed how the

profit is distributed under the lost-profit and unjust-enrichment doctrines in the out-of-equilibrium event of infringement and concluded that the unjust enrichment rule is superior. However, they did not analyze injunctions.

Our own analysis of liability and property rules differs from the earlier literature in that we focus on *equilibrium* profits. We assume frictionless bargaining, which leads to *efficient* use of the intellectual property, and are solely interested in the liability and property rules for their effect on the division of profit. Infringement will never occur in equilibrium, but the possibility of infringement sets the ''threat points'' for establishing licenses. Our focus is on equilibrium profit because that is what determines incentives to innovate.

Our perspective is that intellectual property rights are exercised as the right to collect license fees by threatening to exclude (under a property rule) or threatening to collect damages (under a liability rule). Provided the research tool owner can collect license fees, he has the incentive to encourage other firms to use the tool in developing products. Legal scholars such as Eisenberg (1989) and Heller and Eisenberg (1998) have been less optimistic about contracting than we are. Their analyses are directed at the *ex post* question of how to ensure that inventions are put to good use even when contracting fails, whereas we assume that contracting will not fail. Injunctions can foreclose the use of research tools when licensing fails, and for this reason Eisenberg argues against giving patentholders injunctive relief for research tools. Instead she proposes that courts impose damages equal to reasonable royalty payments. Merges (1996) takes a different position, arguing that to exclude injunctive relief and to rely exclusively on damage remedies would put an unmanageable burden on the courts to set damages or compulsory licensing fees in a way that serves the public interest. This problem can be avoided by permitting injunctions. We also conclude that a property rule can be superior to a liability rule for research tools, but for a different reason, namely, that damages consistent with the prevailing doctrine can be too low.

The article is organized as follows. In Section 2 we discuss the legal basis for the prevailing liability and property regimes. In Section 3 we present a stylized model in which a firm has developed a proprietary research tool that is needed to develop a commercial product.[2] We discuss how the division of profit depends on the remedies for infringement and the opportunity to seek injunctions. In Section 4 we suppose that there is an alternative technology to the proprietary research tool, but that developing the product is more costly when using the alternative tool. This possibility changes our analysis of injunctions, but not of the damage doctrines. In Section 5 we discuss the complexities that arise when multiple research tools are required for each proprietary product. Section 6 examines the case where the patentholder can compete in developing the commercial product. In Section 7 we present a more general model that subsumes research tools and other intellectual property as special cases.

2. Legal doctrines: damages and injunctions

■ **Damage doctrines.** The case law enunciates two doctrines of damages, ''unjust enrichment'' and ''lost profit/reasonable royalty.'' These doctrines appear to be aimed at different objectives. The doctrine of unjust enrichment is focused on a just punishment for the infringer, who is required to disgorge all the profits from infringement. In contrast, the doctrine of lost profit seems aimed at compensating the patentholder, so

[2] The model has the cumulative features of Scotchmer (1991), and Green and Scotchmer (1995), who implicitly assumed a property rule and discussed how patent breadth (the probability of infringement) affects the terms of licensing. Their models extend to research tools, but they do not discuss liability rules.

as to maintain his incentives to invest in R&D (*England* v. *Deere & Co.,* 221 F. Supp. 319, 1963). Before 1946, when the current statutory rules on damages took form, the courts appear to have given greater weight to unjust enrichment. In the postwar period the courts have relied exclusively on the lost-profit/reasonable-royalty doctrine. In that doctrine, the sole basis for recovery is the patentee's damages and not the infringer's profits, though the latter may be relevant evidence for computing the patentee's actual damages or a reasonable royalty (e.g., *Zegers* v. *Zegers, Inc.,* 458 F.2d 726, 1972).

Unjust enrichment. Under this doctrine, the patent owner is entitled to recover profits realized by the infringer on the theory that the infringer should not profit from his wrongdoing. The infringer is viewed as holding these profits ''in constructive trust'' for the infringed party. This doctrine was prominent in the late part of the 19th century and was used as late as World War II (*Littlefield* v. *Perry,* N.Y. 1875, 188 U.S. 205; *Amusement Corp. of America* v. *Mattson,* C.C.A. Fla. 1943, 138 F.2d 693). In most case law, the measure of unjust enrichment was the profits realized by the infringer (e.g., *Leman* v. *Krentler-Arnold Hinge Last Co.,* 284 U.S. 448, 1932). However, a number of cases enunciated the subtler principle that the measure of unjust enrichment should be the advantage gained by using the infringed invention instead of other available, nonproprietary alternatives.[3]

Lost profit and reasonable royalty. This doctrine shifts the focus from the infringer's profits to the patentee's loss (*Yale Lock Mfg. Co.* v. *Sargent,* 117 U.S. 536, 1886). The doctrine as currently applied was enunciated in *Panduit Corp.* v. *Stahlin Bros Fibre Works* (575 F.2d 1152, 1978). The court stated that the patentee is entitled to recover ''actual damages'' (also referred to as ''lost profit'') or, when these cannot be proved, not less than a ''reasonable royalty.'' The principle is to restore the patentee to the position ''but for'' the infringement. Whether lost profit is lost sales or lost licensing revenues depends on whether the owner would have developed the application himself or would have licensed to another firm. From an evidentiary point of view, this distinction would be hard for courts to assess.[4]

Not surprisingly, despite judicial efforts to identify the relevant considerations in setting a reasonable royalty (e.g., *Georgia-Pacific Corp.* v. *United States Plywood Corp.,* 38 F. Supp. 1116, 1970), the doctrine has proved difficult to implement in a consistent and predictable manner (Conley, 1987). In this article we will make a stronger criticism: when the source of profit is licensing revenue, the doctrine involves a circularity, with the consequence that a whole range of damage measures may be logically consistent with it. To emphasize this circularity, we shall refer to ''lost royalty'' instead of ''reasonable royalty.''

□ **Injunctions.** Under a property rule, the patentholder can sue to enjoin an infringing use of the proprietary research tool. In the model below, we assume that the injunction precipitates a settlement. If the research tool is the sole means to develop the enabled product, the settlement will be more favorable to the patentholder if costs have already been sunk by the infringer. Thus the patentholder will have an incentive to delay the injunction. But if there is a substitute for the research tool (for example, a

[3] For example, *Mowry* v. *Whitney,* 81 U.S. 620, 1872; *Horvath* v. *McCord Radiator and Mfg. Co.,* 100 F.2d 326, 1938; *Gordon Form Lathe Co.* v. *Ford Motor Co.,* C.C.A. Mich., 133 F.2d 487, 1943.

[4] Panduit addressed the evidentiary problem by requiring the patent owner to establish four things in order to recover the profit on lost sales: a demand for the patented product, that there were no acceptable noninfringing substitutes, a manufacturing and marketing capability to supply the market, and the profit that would have been made on lost sales.

research tool that is less efficient), we argue that the patentholder's incentive to delay is reversed or muted.

Delay is constrained by the *doctrine of laches.* The right to enjoin can be forfeited if it is not exercised in a timely manner, and if the patentee's unreasonable delay caused the injury to the infringer (*Columbia Broadcasting System, Inc.* v. *Zenith Radio Corp.*, 391 F. Supp. 780, 1975). A defense of laches is more likely to be granted to an infringer if he made significant investments during the period of delay.[5] Once sufficient investments have been made, the infringer can sometimes force the issue by asking for a declaratory judgment. The goal of such a suit is a ruling of patent invalidity or noninfringement. A declaratory judgment suit is unlikely if the infringement can be hidden, or if there are many targets for an infringement suit. But it is plausible when there is a single, visible infringer—or after the infringement is discovered by the patentholder. In fact, the courts have held in a series of recent cases that a delay of six years triggers a rebuttable *presumption* of laches and shifts the burden of proof to the patentee to show that the defense of laches does not apply.[6]

In addition to laches, an infringer may invoke the related defense of estoppel. Estoppel can be invoked if the patent owner made representations by statements or conduct that implied the patent would not be enforced, and if the defendant relied upon them and suffered injury as a result.[7] Unlike laches, a defense of estoppel does not require unreasonable delay by the patent owner, and it can be invoked at any time.

According to interviews we conducted with patent counsel in biotechnology firms, the owner of a research tool typically learns about infringement when the infringer conducts field trials, which usually begin about halfway in the development process and, presumably, after some of the development costs have been sunk. Thus it is reasonable to assume that there is a lower bound to the proportion of the infringer's costs that must be sunk before the patentholder can seek an injunction.

We know of no cases establishing whether a product developed with a proprietary research tool infringes the patent. For process patents, the law is clear: a product that is manufactured with an unlicensed proprietary process constitutes an infringement. The patentholder on the process can sue for damages or enjoin the production and selling of the product. However, we know of no cases establishing rules for research tools, where the patent would be infringed during *development* of the commercial product rather than during manufacture. In the analysis that follows, we suppose that the patentholder can seek an injunction and *ex post* settlement if he detects infringement during development, but not afterward. Even if there were a right to enjoin or collect damages afterward, there is a serious evidentiary problem of establishing that the research tool was used.[8]

3. Licensing a research tool

■ In this section we suppose that there is one research tool and a nonanonymous user with whom the tool owner will bargain. (In a later section we suppose that there

[5] *Rome Grader & Machinery Corp.* v. *J.D. Adams Mfg. Co.,* 135 F.2d 617, 1947; *Whitman* v. *Walt Disney Productions, Inc.,* 148 F.Supp. 37, 1957; *Siemens Aktien-gesellschaft* v. *Beltone Electronics Corp.,* 381 F.Supp. 57, 1974.

[6] *Jensen* v. *Western Irr. and Mfg., Inc.,* C.A. Or. 1980, 650 F.2d 165; *Lemelson* v. *Carolina Enterprises, Inc.,* D.C. N.Y. 1982, 541 F.Supp. 645; *Advanced Cardiovascular Systems, Inc.* v. *Scimed Life Systems, Inc.,* C.A. Fed. (Minn.) 1993, 988 F.2d 1157.

[7] See *Studiengesellschaft Kohle mbH* v. *Eastman Kodak Co,* C.A. Tex. 1980, 616 F.2d 1315. For more extensive references to the case law on laches and estoppel, see USCA (1984), sections 282 and 286.

[8] This evidentiary problem is not unique to research tools, however. It applies to all process patents. In some countries the burden of proof is switched to the defendant in infringement cases involving process patents in order to deal with this problem. It may be advisable to adopt such a rule for research tools.

are several research tools.) The research tool is owned by a patentholder, firm 1, and the tool is needed by a second firm (a potential infringer, firm 2) to develop a commercial product. The product will have commercial value v and can be developed by the potential infringer at cost c. We say that *investment is efficient* if $v - c \geq 0$, and in this section we restrict attention to projects in which investment is efficient. For the moment we assume that the patentholder specializes in research tools and does not have the expertise to use the tool in developing the commercial product. Thus the patentholder's only prospect for profit is through licensing.

We assume that the parties will achieve *ex post* efficiency. Once intellectual property is invented, the patentholder can profit by using it efficiently. The owner will license on terms that the users will accept, since it is better to license at a low price than not to license at all. Thus, with frictionless contracting, the patent does not jeopardize development of second-generation products. However, there is no guarantee that the patentholder's costs will be covered, and that is why it is desirable to maximize his profit, subject to the self-imposed constraint that second-generation products are not jeopardized.

Unauthorized development of the product by firm 2 is an infringement of the research tool. If no license agreement is reached, then under the liability regime, firm 2 must either forgo his product or develop it without authorization and pay damages afterward, say d. If he infringes under the property rule, he will be enjoined after investing some portion of costs, and the firms will reach a settlement. Neither firm can make a take-it-or-leave-it offer in any negotiation. Rather, they bargain for a license agreement in the shadow of what would happen if no bargain is struck, which determines their ''threat points.'' The bargining surplus is always shared according to $(\lambda, 1 - \lambda)$, $0 < \lambda < 1$.

We first discuss the liability regime. If the damages were high enough to deter infringement, then the threat points for the licensing negotiation would be (0, 0), and the bargaining surplus would be the social surplus $v - c$. The license would lead to profits of $(\lambda(v - c), (1 - \lambda)(v - c))$ for the two firms respectively.[9] This would be relevant, for example, under the doctrine of unjust enrichment, if infringement would be deterred. If damages were not high enough to deter infringement, the threat points for the licensing negotiation would be $(d, v - c - d)$, where d represents the damages awarded. See Figure 1.

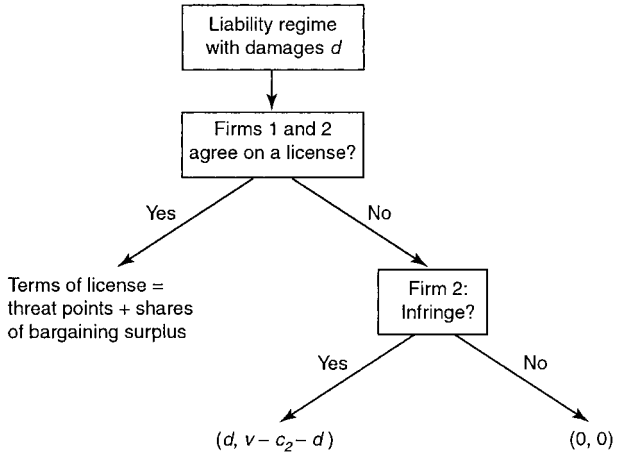
If a license is achieved, the license fee is L. The license fee establishes how the surplus $v - c$ is shared by the two firms and, in particular, whether the patentholder collects the full profit surplus, which is $L = v - c$. Licensing will always occur in equilibrium, but the equilibrium license fee L will depend on the doctrine of damages through the threat points, which reflect the prospective damages d. We propose that the following hypothesis is a good assessment of how the damages rules would be interpreted for research tools:

Hypothesis 1. Damages d are consistent with the lost-royalty doctrine if $d \in [0, v - c]$ and equilibrium license fees satisfy $L = d$. Damages d are consistent with the unjust-enrichment doctrine if $d = v - c$.

The argument behind the hypothesis is as follows. Regarding lost royalty, suppose that the anticipated damages satisfy $d \in [0, v - c]$. Then the patentholder has no incentive to license at $L < d$, and at any higher fee, firm 2 would decline the license

[9] If there were several potential developers, the patentholder might auction the right to use the patent. But due to the patentability of the commercial product, the patentholder can still not collect all profit (Scotchmer, 1996). One can think of λ as a parameter that reflects the maximum he can collect.

FIGURE 1
LICENSING A RESEARCH TOOL



and pay damages *ex post.* Hence the license fee must satisfy $L = d$. Symmetrically, if the license fee would satisfy $L \in [0, v - c]$, and firm 2 infringes the patent, then lost royalty is L, which becomes the damages, $d = L$. But this argument is self-referential. For any $d \in [0, v - c]$ there is an equilibrium with a license at price $L = d$. No other measure of damages is consistent with the lost-royalty doctrine. If $d > v - c$, then d cannot be interpreted as lost royalty. Firm 2 would never agree to such a royalty, since it would then earn negative profit. The argument for the hypothesis on unjust enrichment is that if firm 2 infringes successfully, then he illicitly earns $v - c$ and must disgorge it.

We use π^{LP} and π^{UR} to designate the patentholder's equilibrium profit under the lost-profit and unjust-enrichment doctrines. For research tools, the patentholder's profit is exactly his license revenue. (For other proprietary products, the profit includes both license fees and market revenues, as in Section 7 below.) The following lemma follows immediately from the hypothesis and bargaining assumption.

Lemma 1 (liability regime). Suppose that a single research tool is required to develop a proprietary commercial product, and that damages are measured as in Hypothesis 1. Any equilibrium profit $\pi^{LP} \in [0, v - c]$ is consistent with the lost-profit doctrine of damages. The patentholder's profit under the unjust-enrichment doctrine is $\pi^{UR} = \lambda(v - c)$ if infringement would be deterred under that doctrine, and $\pi^{UR} = v - c$ if infringement would not be deterred.

Thus, the unjust-enrichment doctrine does a better job of protecting the patentholder if infringement would not be deterred, but otherwise the two doctrines cannot be ranked. The lost-profit doctrine is unreliable in that there are multiple equilibria, with different damages and distributions of profit.

We now turn to how and whether the possibility of injunctions can improve on either of the liability rules. Under a property regime, we assume that the patentholder can enjoin an infringing research program before the commercial product is complete. Without a settlement, the infringer is permanently barred from completing or marketing the commercial product. But it will be rational for the firms to reach a settlement, since otherwise neither will profit from the new product. We assume that they will bargain over the surplus remaining at the time of injunction, and that they settle according to

bargaining shares (λ, $1 - \lambda$). The bargaining surplus at settlement depends on how much of the infringer's cost has been sunk.

We do not model the strategic behavior surrounding injunctions, but we interpret the relevant aspects of the law to mean that there is some proportion of cost, say f, $0 \leq f \leq 1$, that must be sunk before the injunction issues. The interpretation is that if less than f is sunk, the infringer cannot seek a declaratory judgment to force an earlier injunction and settlement. If more than f is sunk, the doctrine of laches will bite. The bargaining surplus at settlement is $v - (1 - f)c$, which is positive, since $v - c$ is positive. The firms' threat points for the bargain are $(0, -fc)$, so their profits including settlement are $(\lambda[v - (1 - f)c], (1 - \lambda)[v - (1 - f)c] - fc)$. If $f = 0$, then the equilibrium profits are the same as if infringement were deterred altogether, namely $(\lambda(v - c), (1 - \lambda)(v - c))$.

We first consider how the firms would like to affect f after the infringing research program has begun, and then we consider whether firm 2 would embark on the infringing research program, knowing how it would turn out. Finally we show how the patentholder's equilibrium profit depends on f. The second part of the lemma says that the patentholder's profit is not monotonic in f.

Let

$$f^* = \min\left\{\frac{(v - c)}{c}\frac{(1 - \lambda)}{\lambda}, 1\right\}. \tag{1}$$

Lemma 2 (injunctions). Suppose that a single research tool is required to develop a proprietary commercial product, and that a property regime is in effect. Then

(i) once infringement has begun, the patentholder prefers to delay injunction and settlement until all the infringer's costs have been sunk ($f = 1$), while the infringer prefers that injunction and settlement occur as early as possible ($f = 0$).

(ii) for $f = 0$ and $f > f^*$, the patentholder's equilibrium profit is $\lambda(v - c)$. For $f \in (0, f^*]$, the patentholder's equilibrium profit is $\lambda(v - (1 - f)c)$.

Proof. (i) follows because equilibrium profits are

$$((\lambda(v - (1 - f)c), (1 - \lambda)(v - (1 - f)c) - fc)).$$

(ii) follows because the patentholder's profit is increasing in f. But if $f > f^*$, then the infringer would end up with negative profit. Anticipating this, he would not begin the infringing research project, and a license agreement would have to be made at the beginning, just as if $f = 0$. In that case, the profit of the patentholder is $\lambda(v - c)$. *Q.E.D.*

The patentholder's equilibrium profit is larger when $0 < f < f^*$ than when $f = 0$ or $f \geq f^*$. Thus, despite Lemma 2(i), the patentholder is better off if the doctrine of laches actually constrains him so that he cannot delay the injunction indefinitely. Without the constraint, the patentee will delay until the end. The prospect of indefinite delay would force an *ex ante* agreement, which the patentholder prefers to avoid.

These lemmas allow us to reach the following conclusion. The statement that the patentholder ''typically prefers'' one regime to another means that profits might be equal under the two regimes, but in ''most'' equilibria, profits are greater under the preferred regime.

Proposition 1 (research tools: liability versus injunctions). Suppose that a single research tool is required to develop a proprietary commercial product, and that damages are measured as in Hypothesis 1.

(i) Suppose that infringement would not be deterred under the unjust-enrichment doctrine. Then the patentholder typically prefers the unjust-enrichment doctrine to either the lost-royalty doctrine or to a property rule.

(ii) Suppose that infringement would be deterred under the unjust-enrichment doctrine. Then the patentholder typically prefers the property rule to the unjust-enrichment doctrine. The lost-profit doctrine leads to multiple equilibria, some with greater profit than under the unjust-enrichment doctrine or property rule, and some with less.

The effectiveness of the property rule in transferring the surplus depends on when the doctrine of laches takes effect, as modelled in the parameter f. Like the lost-royalty rule, the property rule is an unreliable vehicle for enforcement unless the laches parameter is interpreted efficiently at f^*.

When $f^* < 1$ it has an interesting interpretation: f^* is proportional to the rate of return on investment, $(v - c)/c$, where the factor of proportionality $(1 - \lambda)/\lambda$ decreases with the patentholder's bargaining power λ. This interpretation provides some guidance to courts as to how to enforce the doctrine of laches in different contexts. For example, if the relative bargaining power $(1 - \lambda)/\lambda$ is proportional to relative firm size (or perhaps cash flow), then the doctrine of laches should take effect sooner in cases where the patentholder is larger (or cash rich) and when the product being developed with the research tool is less valuable.

Remark 1. To achieve maximum profit for the patentholder, the doctrine of laches should take effect sooner when products are less valuable or when the patentholder has greater bargaining power.

We have assumed that either the property regime or the liability regime applies, but not both. In practice, patentholders often seek injunctions and damages at the same time. Damages are usually calculated with regard to market sales before the injunction. With research tools, nothing is bought and sold before the injunction, so that issue does not arise (assuming that the injunction occurs before production begins). If injunctions were appended to a liability regime in our model, the injunction could no longer force a settlement. Instead of bargaining over the remaining surplus, $v - (1 - f)c$, as we have assumed, damages would be paid. One party or the other would prefer damage payments to negotiation, so the threat of injunction would not change what would happen under the liability rule.

4. Licensing in the presence of substitutes

■ Our analysis so far has assumed that the research tool is indispensable. For some research tools, such as a genetic sequence required to develop a medical therapy, this is so. For others, such as methods for inserting foreign genetic material into cells, there may be substitutes. The threat points for *ex ante* licensing are then established by the costliness of avoiding the proprietary tool. We shall now assume that without the tool, development of the commercial product costs σ instead of c, where $\sigma > c$. The size of σ can be influenced by the breadth of the patent on the research tool, since a broader patent makes it more difficult to develop a close substitute. The *profit surplus* in this situation is $\sigma - c$ rather than $v - c$ (provided $v > \sigma$), and $\sigma - c$ is the most that the patentholder would hope to receive. A modified hypothesis on damages is

Hypothesis 2. Damages d are consistent with the lost-royalty doctrine if $d \in [0, \sigma - c]$ and equilibrium license fees satisfy $L = d$. Damages d are consistent with the unjust-enrichment doctrine if $d = \sigma - c$.

As we point out in the proposition below, the liability doctrines operate very much as above, except that the bargaining surplus is $(\sigma - c)$ rather than $(v - c)$. However, there is an interesting difference in how the property rule operates. In the previous section, as time passed without injunction and settlement, the bargaining surplus kept increasing because the infringer continued to sink costs in the commercial product. Thus delay was profitable to the patentholder. When a substitute tool is available, delay may either increase or decrease the bargaining surplus, depending on the cost of switching between tools. If there is no switching cost, our previous conclusion is overturned: Delay decreases the bargaining surplus, and the patentholder wants to avoid delay. More generally, the bargaining surplus consists of two parts: the cost that can be saved by using the proprietary tool rather than the substitute, which decreases with time, and the holdup value due to the switching costs, which increases with time.

Formally, let α be the fraction of development costs that must be incurred again if firm 2 switches to the alternative tool, and let f be the fraction of development that has already occurred when the infringement is enjoined. After injunction, firm 2 could continue development with the inferior technology, bearing costs $(1 - f)\sigma$, which is wasteful in amount $(1 - f)(\sigma - c)$. In addition he would bear a switching cost αfc. A settlement will allow the firms to avoid both costs. The bargaining surplus at the time of the injunction is thus $(1 - f)(\sigma - c) + \alpha fc$. The patentholder's profit at *ex post* settlement is his share of the bargaining surplus, since his threat point is zero. The patentholder's profit is thus $\lambda[(1 - f)(\sigma - c) + \alpha fc]$.

Proposition 2 (research tools with substitutes: liability and injunctions). Suppose that a commercial product can be developed either with a proprietary research tool at cost c, or with a noninfringing substitute at greater cost σ, and that damages are measured as in Hypothesis 2.

(i) Suppose that infringement would not be deterred under the doctrine of unjust enrichment. Then the patentholder prefers that doctrine to a property rule, and typically prefers it to the lost-royalty rule.

(ii) Suppose that infringement would be deterred under the unjust-enrichment doctrine. Then the patentholder typically prefers that doctrine to a property rule. There are multiple equilibria under the lost-profit rule, some of which provide more profit to the patentholder than the unjust-enrichment rule or property rule, and some less.

Proof. The patentholder's profit under the property rule is no greater than $\lambda(\sigma - c)$. Whether the patentholder's profit increases or decreases with delay depends on α. The patentholder's profit is increasing or decreasing in f according to whether α is larger or smaller than $(\sigma - c)/c$. Thus, if $\alpha \geq (\sigma - c)/c$, the patentholder's profit is no greater than $\lambda\alpha c$ (which is the profit at settlement, $\lambda[(1 - f)(\sigma - c) + \alpha fc]$, evaluated at $f = 1$), which is no greater than $\lambda(\sigma - c)$. If $\alpha < (\sigma - c)/c$, profit is no greater than $\lambda(\sigma - c)$ (which is the profit at settlement, $\lambda[(1 - f)(\sigma - c) + \alpha fc]$, evaluated at $f = 0$).

Reasoning as in Proposition 1, the patentholder earns profit anywhere in the interval $[0, \sigma - c]$ under the lost-royalty doctrine, whereas under the unjust-enrichment doctrine, he earns either $\lambda(\sigma - c)$ or $\sigma - c$ according to whether infringement would or would not be deterred. Part (i) follows because the patentholder earns $(\sigma - c)$ under the unjust-enrichment doctrine; profit is bounded above by $\lambda(\sigma - c)$ under the property rule; and profit can be anything in the interval $[0, \sigma - c]$ under the lost-royalty doctrine. Part (ii) follows because the patentholder earns either $\lambda(\sigma - c)$ under the unjust-enrichment doctrine; can earn any profit in the interval $[0, \sigma - c]$ under the lost-profit doctrine; and earns no more than $\lambda(\sigma - c)$ under a property rule. *Q.E.D.*

5. Licensing several tools

■ We now briefly examine how the ideas of Section 3 apply when many research tools are required for the commercial product, rather than only one. We first maintain our hypothesis that the market for licenses is ''nonanonymous,'' so that the user negotiates with each tool owner. We then consider the case of anonymous licensing.

□ **Nonanonymous licensing.** Suppose that there are N tools, indexed $i = 1, \ldots, N$, all of which are required to develop a commercial product of value v. In the case of bioengineering, the tools might be a sequence needed for gene expression, a sequence that codes for a protein, and a method of gene insertion. The natural hypothesis on damages, analogous to the one above, is

Hypothesis 3. Suppose $\{L_j\}_{j=1}^N$ are equilibrium license fees for a particular user. Then damages $\{d_j\}_{j=1}^N$ are consistent with the lost-royalties doctrine if $d_j = L_j$ for $j = 1, \ldots, N$, and $(v - c) - \Sigma_{j=1}^N L_j \geq 0$. Damages $\{d_j\}_{j=1}^N$ are consistent with the unjust-enrichment doctrine if $d_j = (v - c) - \Sigma_{i \neq j} L_i$.

The hypothesis on the lost-royalty doctrine reflects the same circularity discussed above. No licensor could license at a price higher than prospective damages, since the licensee would infringe rather than take the license. And the licensor has no incentive to agree to a lower license fee, hence $d_j = L_j$. The license fees are indeterminate as regards the division of profit not only between licensors and licensees, but also among tool owners. As before, license fees that more than exhaust the value of the application could not arise in equilibrium, and could not be ''lost royalty.''

We now work out the consequences of the hypothesis for unjust enrichment. For the case that infringement would be deterred under the unjust-enrichment doctrine, we assume that the bargaining shares are $\{\lambda_j\}_{j=0}^N$, where λ_0 is the bargaining share of the user. Then if infringement would be deterred, absent a complete set of licenses, and if the user gets a positive bargaining share $\lambda_0 > 0$, the equilibrium license fees will not exhaust the profit surplus in equilibrium. Damages and license fees must simultaneously satisfy $d_i = (v - c) - \Sigma_{j \neq i}^N L_i$ and $L_j = \lambda_j(v - c)$ for $i, j = 1, \ldots, N$. These conditions imply that each tool owner's potential damages are equal to the unpaid license fee plus the profit surplus that the user receives in equilibrium:

$$d_i = \left(1 - \sum_{j \neq 0,i}^{N} \lambda_j\right)(v - c) = (\lambda_i + \lambda_0)(v - c).$$

Thus the potential damages exhaust more than the profit (but damages are not paid in equilibrium), while license fees exhaust less than the profit (the user gets a bargaining share).

If infringement would not be deterred, then damages take away all the infringer's profit, and $L_j = d_j$ would hold for each tool j. If the license fee were higher than prospective damages, the licensee would prefer to pay damages rather than license. If the license fee were lower than prospective damages, then the tool owner would withhold the license and collect damages instead. Thus

$$(v - c) - \sum_{j=1}^{N} L_j = (v - c) - \sum_{j=1}^{N} d_j = 0.$$

We summarize these conclusions as

Lemma 3 (liability regime). Suppose that several proprietary research tools are required to develop a commercial product. Suppose that the market for research tools is nonanonymous, so that tool owners and licensees bargain for user-specific license fees, and that damages are measured as in Hypothesis 3. Then

(i) Under the lost-profit doctrine of damages, there are multiple equilibria with different license fees, and the tool owners will not necessarily collect all the profit surplus.

(ii) Under the unjust-enrichment doctrine of damages, tool owners will collect all the profit surplus if infringement is not deterred under that doctrine, but not otherwise.

Now we investigate injunctions. When a single tool owner enjoins an infringer from developing a product, the infringer and all the other tool owners are potentially deprived of profit. We again use the bargaining shares $\{\lambda_j\}_{j=0}^N$, where $\lambda_0 > 0$ is the bargaining share of the user. Any one of the tool owners can withhold a license, leading to injunction and settlement, and this is known to all of them. We assume that the threat point for every tool owner's license is what would happen if no licenses were issued and infringement went forward to injunction and settlement.

The definition of f^{**} below, and Lemma 4 that follows, are similar to those in Section 3, except that we must substitute ''the tool owners'' for ''the patentholder,'' and the tool owners' joint profit, $(v - c)\sum_{j=1}^N \lambda_j$, for the patentholder's profit. With infringement, injunction, and settlement, the tool owners' joint profit at settlement would be $(\sum_{j=1}^N \lambda_j)(v - (1 - f)c)$, and the infringer's profit, accounting for his bargaining share at settlement and his sunk costs, would be $(1 - \sum_{j=1}^N \lambda_j)(v - (1 - f)c) - fc$.

Let

$$f^{**} = \min\left\{\frac{(v - c)}{c}\frac{\left(1 - \sum_{j=1}^N \lambda_j\right)}{\sum_{j=1}^N \lambda_j}, 1\right\}. \tag{2}$$

No infringement will occur if $f > f^{**}$ because the infringer's profit would be negative. With no infringement ($f > f^*$), each tool owner's ''threat point'' for a licensing negotiation is zero, and equilibrium profits are $\lambda_j(v - c)$, $j = 1, \ldots, N$. The tool owners' joint profit is $(\sum_{j=1}^N \lambda_j)(v - c)$, which is less than $(v - c)$ since $\sum_{j=1}^N \lambda_j = 1 - \lambda_0$. That is, if f is too large (injunction occurs too late), then infringement would be deterred. Deterrence leads to an upfront settlement in which the user gets a positive profit share.

Lemma 4 (injunctions). Suppose that several research tools are required to develop a proprietary commercial product, and that a property regime is in effect. Then

(i) Once infringement has begun, the tool owners prefer to delay injunction and settlement until all the infringer's costs have been sunk ($f = 1$), whereas the infringer prefers that injunction and settlement occur as early as possible ($f = 0$).

(ii) For $f = 0$ and $f > f^{**}$, the tool owners' joint equilibrium profit is $(\sum_{j=1}^N \lambda_j)(v - c)$. For $f \in (0, f^{**}]$, the tool owners' joint equilibrium profit is $(\sum_{j=1}^N \lambda_j)(v - (1 - f)c)$.

This argument, together with the preceding lemma, leads us to the following proposition.

Proposition 3 (nonanonymous licensing of several tools). Suppose that several proprietary research tools are required to develop a commercial product. Suppose that the

market for research tools is nonanonymous, so that tool owners and licensees bargain for user-specific license fees, and that damages are measured as in Hypothesis 3. Then

(i) if infringement would not be deterred under the unjust-enrichment doctrine, the tool owners as a group typically earn more profit under the unjust-enrichment doctrine than under the lost-profit doctrine or a property rule.

(ii) if infringement would be deterred under the unjust-enrichment doctrine, the tool owners as a group typically earn less profit under the unjust-enrichment doctrine than under the property rule. The lost-profit doctrine leads to multiple equilibria, some with greater profit for the tool owners than under the unjust-enrichment doctrine or property rule, and some with less.

□ **Anonymous licensing.** The difference between anonymous and nonanonymous licensing is that with anonymity there is a market by which to evaluate lost royalties. By anonymous licensing we mean that each licensor faces a demand curve for his licenses, as when there are many potential applications. He sets a common fee for all users. Anonymity can be reflected in the notion of damages under the lost-profit doctrine, but it vanishes with the unjust-enrichment doctrine. Unjust enrichment of necessity refers to the infringer's specific circumstances, in particular $(v - c)$.

We make the following hypothesis on damages under the lost-profit doctrine when tools are licensed anonymously in markets with common prices.

Hypothesis 4. Suppose $\{L_j\}_{j=1}^N$ are anonymous equilibrium license fees. Any nonnegative damages $\{d_j\}_{j=1}^N$ are consistent with the lost-profit doctrine if $d_j = L_j$, $j = 1, \ldots, N$. Damages $\{d_j\}_{j=1}^N$ are consistent with the unjust-enrichment doctrine if $d_j = (v - c) - \sum_{i \neq j} L_i$.

Hypothesis 4 differs from Hypothesis 3 in that it does not impose for any particular user that $(v - c) - \sum_{j=1}^N L_j \geq 0$. If an infringer has a project with low net value, $v - c$, he might be dissuaded from investing if the license fees are too high. This is because the court could reasonably assess lost royalty by looking at the fees charged to other firms, rather than by considering what license terms the two firms ''would have'' reached, absent the infringement. This is the only case we consider where investment might not be efficient. The inefficiency arises from anonymous pricing.

The analyses of injunctions and the unjust-enrichment doctrine are exactly as for nonanonymous licensing. We thus have the following proposition:

Proposition 4 (anonymous licensing of several tools). Suppose that several proprietary research tools are required to develop a commercial product. Suppose that the market for research tools is anonymous, and that damages are measured as in Hypothesis 4. Then under the lost-profit (lost-royalty) doctrine, a commercial application might not be developed even though it provides positive surplus. Profits for the tool owners can be compared under the different enforcement regimes exactly as in Proposition 3, parts (i) and (ii).

As already mentioned, the reason that investment is always efficient with nonanonymous bargaining is that the court has more latitude in assessing ''lost royalty'' *ex post* than with anonymous licensing. The court will never assess higher lost royalties than the potential licensee could have paid, as that would contradict the notion that the potential licensee ''could have'' licensed at that price.

An advantage of the unjust-enrichment doctrine is that it undermines anonymity and implicitly encourages licensors and the potential infringer to agree on terms that would allow every efficient investment to be made. The unjust-enrichment doctrine permits the licensors to discriminate in their license fees according to the value of the applications. (Of course we are ignoring the bargaining compexities that arise from an

inability of the potential infringer to communicate his net value ($v - c$) credibly in this negotiation.)

6. Competition from the patentholder

■ We now suppose that both the patentholder and the potential infringer are capable of developing the commercial product, although one may be more efficient (have lower costs) than the other. Infringement might lead to a race between the patentholder and a potential infringer.

Suppose that the patentholder and potential infringer have respective costs c_1 and c_2. The *profit surplus* is now $\max\{v - c_1, v - c_2\}$. Efficiency has two aspects: the commercial product should be developed whenever the profit surplus is positive, but in addition, it should be developed by the lower-cost firm, which might or might not be the patentholder.

We will assume that if the infringer and patentholder race for the commercial product, the patentholder wins with probability p. This probability might depend on the relative costs, but we suppress this dependence to avoid notation. In equilibrium the patentholder's profit π^{LP} will either be licensing fees or the net value of the commercial product if the patentholder develops it himself, and it might involve elements of both.

Our hypothesis on damages is now given in Hypothesis 5.

Hypothesis 5. Under the unjust-enrichment doctrine and lost-profit (royalty) doctrine, respectively, damages are measured as

$$d^{UR} = v - c_2 \tag{3}$$

$$d^{LP} = \pi^{LP}. \tag{4}$$

The damages will be paid only if the infringer actually achieves the commercial product. If the patentholder races against the infringer and wins, then we assume that no damage suit is brought and no damages are paid. See Figure 2. Thus infringement does not always result in damages, and the profits in the proofs below should reflect this.

Lemma 5 (lost-profit doctrine: research tools with competition). Suppose that the patentholder and potential infringer are both capable of developing the commercial product at respective costs c_1, c_2. Suppose that damages are given by (4). Then under the lost-profit doctrine the patentholder's equilibrium profit can be any $\pi^{LP} \in [v - (c_1/p), v - c_2]$ if the infringer has lower costs, and it is $\pi^{LP} = v - c_1$ if the patentholder has lower costs.

Proof. First we argue that the patentholder would not race against an infringer. If he raced, he would receive damages with probability $(1 - p)$, and his expected profit in the race would be $pv - c_1 + (1 - p)d^{LP} = pv - c_1 + (1 - p)\pi^{LP}$. This would be the threat point for achieving a license to avoid the infringement. The efficiency surplus available by licensing is cost avoidance, namely, $\max\{c_1, c_2\}$. Our bargaining rule is that the firms divide the efficiency surplus in shares $(\lambda, 1 - \lambda)$. Thus the patentholder's equilibrium profit must satisfy

$$\pi^{LP} = pv - c_1 + (1 - p)\pi^{LP} + \lambda \max\{c_1, c_2\}. \tag{5}$$

Solving for π^{LP} on the assumption that the patentholder will race against the infringer, the equilibrium profit and damages satisfy

$$\pi^{LP} = \frac{1}{p}[pv - c_1 + \lambda \max\{c_1, c_2\}] \tag{6}$$

$$d^{LP} = \frac{1}{p}[pv - c_1 + \lambda \max\{c_1, c_2\}]. \tag{7}$$

Now test the premise: Does the patentholder want to race against the infringer? If the patentholder stays out of the race and collects d^{LP} with probability 1 rather than with probability p, also giving up the possibility that he wins the race, he earns greater expected profit: $d^{LP} > pv - c_1 + (1 - p)d^{LP}$, where the inequality follows from (7). Thus the patentholder will not race against an infringer under the measure of damages in (4).

Suppose then that the patentholder would not race against the infringer. The patentholder's equilibrium profit with licensing is his ''threat point'' d^{LP} plus his bargaining share of any efficiency surplus. Thus his equilibrium profit satisfies $\pi^{LP} = d^{LP}$ if $c_2 < c_1$, and $\pi^{LP} = d^{LP} + \lambda(c_2 - c_1)$ if $c_1 \leq c_2$.

If the potential infringer is the more efficient firm ($c_2 < c_1$), there is no efficiency surplus to share in a licensing bargain. Any level of damages $d^{LP} = \pi^{LP}$ is consistent with equilibrium, provided the premises hold: infringement is not deterred ($v - c_2 - d^{LP} \geq 0$) and the patentholder prefers not to race ($pv - c_1 + (1 - p)d^{LP} \leq d^{LP}$). Thus, for the case that the infringer is the more efficient firm, any d^{LP}, $\pi^{LP} \in [v - (c_1/p), v - c_2]$ are consistent with equilibrium. The equilibrium profit π^{LP} is collected as a license fee.

On the other hand, if the patentholder is the more efficient firm ($c_1 \leq c_2$), and if infringement would occur, absent a license, then the patentholder's equilibrium profit would have to satisfy $\pi^{LP} = d^{LP} + \lambda(c_2 - c_1)$. But this is inconsistent with (4), so damages cannot lead to infringement, absent a license. The only possibility is that $d^{LP} = \pi^{LP} = v - c_1$, and infringement would be deterred. *Q.E.D.*

The content of Lemma 5 is that if the patentholder is more efficient at working his patent, then he will earn the same profit as if no potential infringer were present. If the potential infringer is more efficient, license fees are indeterminate (as in Section 3), but the license fees cannot be too low because the patentholder would then develop the product himself, even in the face of infringement.

We now turn to the doctrine of unjust enrichment. The following lemma says that there are two rather disjoint circumstances in which the patentholder can collect the full surplus: if he is the more efficient firm and infringement is deterred, and if he is the less efficient firm but infringement is not deterred. Otherwise the potential infringer gets part of the cost savings that are available by licensing.

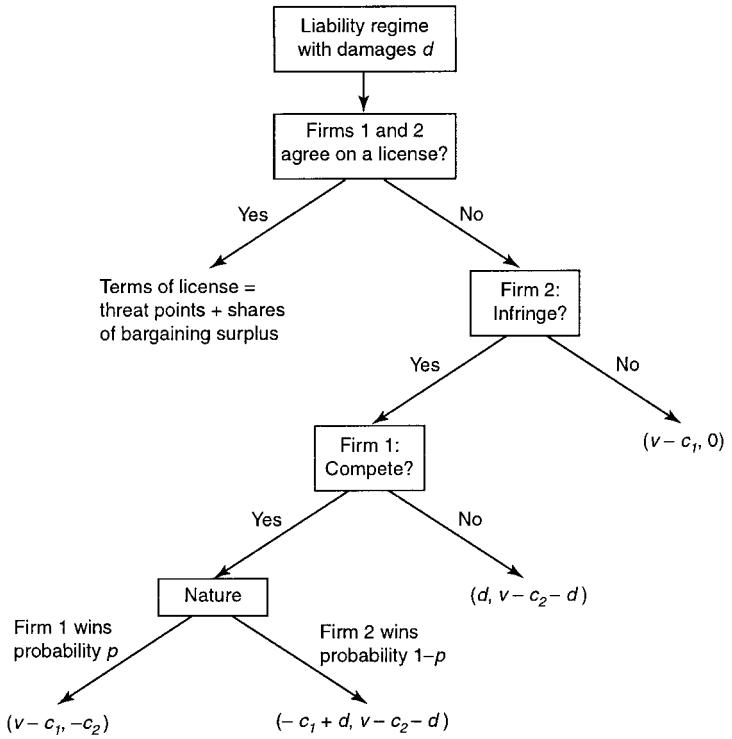
Lemma 6 (unjust-enrichment doctrine: research tools with competition). Suppose that the patentholder and potential infringer are capable of developing the commercial product at respective costs c_1, c_2. Suppose that damages are given by (3).

(i) Under the unjust-enrichment doctrine, the patentholder collects the full surplus, $\max\{v - c_1, v - c_2\}$, in two circumstances: if he is the more efficient firm and infringement is deterred, and if he is the less efficient firm but infringement is not deterred.

(ii) If $c_1 \leq c_2$ and infringement is not deterred, absent a license, the patentholder collects $\pi^{UR} = (v - c_2) + \lambda(c_2 - c_1)$ (less than the full surplus) in equilibrium.

(iii) If $c_1 > c_2$ and infringement is deterred, absent a license, the patentholder collects $\pi^{UR} = (v - c_1) + \lambda(c_1 - c_2)$ (less than the full surplus) in equilibrium.

FIGURE 2
LICENSING TO AVOID A RACE



Proof. Suppose first that infringement would be deterred. Then if the patentholder is the more efficient (lower-cost) firm, deterrence leaves him free to pursue the invention on his own, and he collects the full surplus $\pi^{UR} = v - c_1 = \max\{v - c_1, v - c_2\}$. If the potential infringer is the more efficient firm, deterrence gives him a holdup right over the cost reduction he can provide. The bargaining surplus is $(c_1 - c_2)$, and the patentholder's profit is $\pi^{UR} = (v - c_1) + \lambda(c_1 - c_2) < v - c_2 = \max\{v - c_1, v - c_2\}$.

Suppose that infringement would not be deterred. If the infringer is the more efficient firm, infringement is a good thing for the patentholder, because he can collect the full surplus $\pi^{UR} = d^{UR} = \max\{v - c_1, v - c_2\} = v - c_2$ as damages. If the patentholder is the more efficient firm, the damage collected *ex post* is $v - c_2 < \max\{v - c_1, v - c_2\}$ (less than the full surplus). The licensing agreement that avoids this outcome has the odd feature that the patentholder pays the infringer not to infringe. He shares with the infringer the cost reduction that the patentholder himself can provide, namely, $c_2 - c_1$. Thus the patentholder receives $\pi^{UR} = (v - c_2) + \lambda(c_2 - c_1)$. *Q.E.D.*

Proposition 5 (research tools: liability in the context of patent races). Suppose that damages are measured as in Hypothesis 5.

(i) If the patentholder is more efficient than the potential infringer, then he may collect less profit under the unjust-enrichment doctrine than under the lost-profit doctrine, and never collects more.

(ii) If the patentholder is less efficient than the potential infringer, and if infringement would not be deterred, absent a license, under the unjust-enrichment doctrine, then the patentholder typically prefers that doctrine to the lost-profit doctrine.

(iii) If the patentholder is less efficient than the potential infringer, and if infringement would be deterred, absent a license, under the unjust-enrichment doctrine, then the patentholder may earn more profit or less profit under that doctrine than under the lost-profit doctrine.

Proof. Parts (i) and (ii) follow from Lemmas 5 and 6. Using the same two lemmas, part (iii) follows because profit under the unjust-enrichment doctrine is $\pi^{UR} = (v - c_1) + \lambda(c_1 - c_2)$, and $v - (c_1/p) < (v - c_1) + \lambda(c_1 - c_2) < v - c_2$. *Q.E.D.*

7. A more general model

■ We now investigate whether the above conclusions apply in other contexts where licensing is the natural use of intellectual property, or whether our conclusions are specific to research tools. To do this we consider a more general model that subsumes research tools and proprietary products as special cases. We again assume that the patentholder and a potential infringer will bargain for a license. If no license is agreed upon, then infringement might occur, followed by a damage award. Whether there will be infringement depends on the prospective damages, and this prospect sets the threat points for licensing, as before.

Suppose that without licensing, the patentholder's monopoly profit is π^M. If an infringer enters the market, the two firms will compete in ways that will be specific to the context. Let π_I^P, π_I^C be the profits earned by the patentholder and infringer with such competition, where the subscript on π denotes (I)nfringement and the superscripts denote (P)atentholder and (C)ompetitor (infringer). In Figure 1, the threat-point payoffs at the bottom of the tree with infringement would be either $(\pi_I^P + d, \pi_I^C - d)$ or $(\pi^M, 0)$.

If licensing entails an efficiency gain, e.g., productive efficiency, the joint profit with licensing will be greater than π^M. Let π^J be the maximum joint profit that the two firms can earn jointly if they produce efficiently and maximize joint profit, e.g., by agreeing to high royalties. We assume that $\pi_I^P + \pi_I^C \leq \pi^J$ and $\pi^M \leq \pi^J$. If $\pi^M < \pi^J$, licensing should occur in equilibrium, since it allows an efficiency gain that increases joint profit. The joint profit can be shared with complete flexibility through a lump-sum transfer.

Damages under the unjust-enrichment doctrine would naturally be measured as $d = \pi_I^C$. However, damages under the lost-profit doctrine are more difficult to assess. The notion of lost profit could have two parts: the amount by which the patentholder's profit on his own activities is diminished by the infringement, and the lost revenue that he should have received through licensing. We shall again assume that infringement is an out-of-equilibrium act, and that lost profit (royalty) is assessed with reference to equilibrium. Admittedly, this notion of lost profit would be difficult for the court to assess, but assessing it seems to be the challenge posed by the doctrine itself. This is why we emphasize that we have an equilibrium theory of damages. Without equilibrium as a reference point, it is unclear what lost profit means.

We let (d^{LP}, π^{LP}) and (d^{UR}, π^{UR}) represent the damages and equilibrium profits of the patentholder that are consistent with the lost-profit and unjust-enrichment doctrines, respectively. It is important to notice that $(\pi_I^P, \pi_I^C, \pi^J, \pi^M)$ are parameters of the economic environment, whereas π^{LP} and π^{UR} are equilibrium values. Since the firms will always license in a way that leads to maximal joint profits π^J, the licensee will earn equilibrium profit $\pi^J - \pi^{LP}$ or $\pi^J - \pi^{UR}$ under the two rules respectively. We again assume that if there is a bargaining surplus to share, the shares are $(\lambda, 1 - \lambda)$.

With this notation, we do not need to include licensing explicitly in our measure of damages, as licensing revenues are incorporated in the equilibrium profit π^{LP}. Our hypothesis on damages, in accordance with the view articulated above, is

Hypothesis 6. Under the unjust-enrichment doctrine and lost-profit (royalty) doctrine, respectively, damages are measured as

$$d^{UR} = \pi_I^C \tag{8}$$

$$d^{LP} = \pi^{LP} - \pi_I^P. \tag{9}$$

We can now characterize the equilibrium profits π^{LP} and π^{UR}. The unjust-enrichment doctrine is the easier one to analyze. The following lemma points out that under the unjust-enrichment doctrine, the patentholder's profit depends on whether infringement would be deterred, absent a license. The patentholder's profit can be higher without deterrence in the circumstance that $\pi_I^C + \pi_I^P > \pi^M$, as could occur with a research tool that cannot be worked by the patentholder. If the research tool cannot be worked by the patentholder, $\pi^M = \pi_I^P = 0$, and $\pi_I^C = \pi^J$.

Lemma 7. Suppose that the measure of damages is given by (8). If infringement would not be deterred under the unjust-enrichment doctrine, the patentholder's equilibrium profit is $\pi^{UR} = (1 - \lambda)(\pi_I^C + \pi_I^P) + \lambda\pi^J$. If infringement would be deterred, the patentholder's equilibrium profit is $\pi^{UR} = (1 - \lambda)\pi^M + \lambda\pi^J$.

Proof. Without deterrence, since the threat points for the licensing agreement are $(d^{UR} + \pi_I^P, 0) = (\pi_I^C + \pi_I^P, 0)$, and the bargaining surplus is $\pi^J - (\pi_I^C + \pi_I^P)$, the patentholder's equilibrium profit is as stated. The argument with deterrence is analogous. *Q.E.D.*

When the patent is on a proprietary product or cost-reducing process, it will generally hold that $\pi^J > \pi_I^C + \pi_I^P$. That is because competition will dissipate some of the joint profit that would be available under a licensing agreement. π^M is the monopoly profit earned by the patentholder without licensing, and π_I^C, π_I^P are the oligopoly profits of the two firms when both use the patentholder's technology and compete in the market. Generally it will be the case that $\pi_I^C + \pi_I^P < \pi^M < \pi^J$.

Proposition 6 (liability doctrines: proprietary products). Suppose that damages are measured as in Hypothesis 6, and that $\pi_I^P + \pi_I^C < \pi^M < \pi^J$. Then, provided infringement would not be deterred under the unjust-enrichment doctrine, the patentholder earns more profit under the lost-profit doctrine than under the unjust-enrichment doctrine. If infringement would be deterred under the unjust-enrichment doctrine, the patentholder earns the same profit under the two doctrines.

Proof. The patentholder's equilibrium profit is equal to the threat point plus λ times the bargaining surplus. Thus the following must hold under the lost-profit doctrine:

$$\pi^{LP} = \pi_I^P + d^{LP} + \lambda(\pi^J - \pi_I^P - \pi_I^C) \quad \text{if } \pi_I^C - d^{LP} \geq 0 \tag{10}$$

$$\pi^{LP} = \pi^M + \lambda(\pi^J - \pi^M) \quad \text{if } \pi_I^C - d^{LP} < 0. \tag{11}$$

However, (10) is inconsistent with (9), so damages cannot satisfy $\pi_I^C - d^{LP} \geq 0$. Thus the patentholder's equilibrium profit satisfies (11). Equations (9) and (11) imply that $d^{LP} = \pi^M + \lambda(\pi^J - \pi^M) - \pi_I^P$. Since $\pi_I^C - d^{LP} < 0$, infringement is deterred. The

patentholder's equilibrium profit is $\pi^{LP} = (1 - \lambda)\pi^M + \lambda\pi^J$, from which the result follows, using Lemma 7. *Q.E.D.*

However, the conclusions are different under the assumptions that naturally apply to research tools, namely, $\pi_I^P = \pi^M = 0$ and $\pi_I^C = \pi^J$. (In the notation of Section 3, $\pi_I^C = v - c$). This is the situation in which the patentholder is (counterintuitively) better off if infringement is not deterred (see Lemma 7). If infringement is not deterred under the unjust-enrichment doctrine, then the patentholder unambiguously prefers it to the lost-profit doctrine. But if infringement would be deterred, then the two doctrines cannot be ranked. Some of the equilibria under the lost-profit doctrine are more profitable than under the unjust-enrichment doctrine. The next proposition replicates the results of Proposition 1 in this more general model.

Proposition 7 (liability doctrines: research tools). Suppose that the measures of damages are given by Hypothesis 6 and that $\pi_I^P = \pi^M = 0$, $\pi_I^C = \pi^J$. Equilibrium is not unique under the lost-profit doctrine, and the patentholder's equilibrium profit can be any $\pi^{LP} \in [0, \pi^J]$. In all equilibria except the most profitable one, the patentholder earns less profit under the lost-profit doctrine than under the unjust-enrichment doctrine, assuming that infringement would not be deterred under the unjust-enrichment doctrine. If infringement would be deterred under the unjust-enrichment doctrine, the patentholder's profit is unique under that doctrine, and it may be greater or lesser than his profit under the lost-profit doctrine.

Proof. The patentholder's equilibrium profit is equal to the threat point plus λ times the bargaining surplus. Thus the following must hold:

$$\pi^{LP} = \pi_I^P + d^{LP} + \lambda(\pi^J - \pi_I^P - \pi_I^C) = d^{LP} \quad \text{if } \pi_I^C - d^{LP} \geq 0 \tag{12}$$

$$\pi^{LP} = \pi^M + \lambda(\pi^J - \pi^M) = \lambda\pi^J \quad \text{if } \pi_I^C - d^{LP} < 0. \tag{13}$$

Equation (12) is the same as (9), so (unlike the previous lemma) damages can satisfy $\pi_I^C - d^{LP} \geq 0$. On the other hand, damages cannot satisfy $\pi_I^C - d^{LP} < 0$ because (13) is inconsistent with (9) under the hypotheses. Since $\pi_I^C - d^{LP} \geq 0$, infringement is not deterred in equilibrium, absent a license. The only restrictions imposed by equilibrium are $\pi^{LP} = d^{LP}$ and $\pi_I^C - d^{LP} = \pi_I^C - \pi^{LP} \geq 0$. Thus damages d^{LP} are consistent in equilibrium with the lost-profits doctrine if and only if $d^{LP} \in [0, \pi^J]$. Using Lemma 7, the result follows. *Q.E.D.*

8. Concluding remarks

■ Our main observation is that infringement of patents on research tools is a real possibility under both doctrines of damages and might also be a credible threat under a property rule, depending on how the doctrine of laches is applied. But, counterintuitively, a credible threat of infringement can increase the patentholder's profit rather than decrease it. Under the unjust-enrichment doctrine, all the profit would be transferred to the patentholder *ex post.* This puts the patentholder in the best possible position. The lost-profit doctrine could also lead to infringement, due to the circularity discussed above. However, it is an unreliable way to measure damages, in that many damage measures are consistent with the doctrine, and most of them are less profitable to the patentholder than the damages consistent with unjust enrichment. Infringement under the property rule is profitable because the patentholder will end up settling a licensing negotiation after the potential licensee (infringer) has sunk costs.

The efficacy of a property rule depends on the earliest date that the infringement will be enjoined. Both parties have legal rights in determining this date, as discussed above. In cases where the research tool is indispensable, delay increases the bargaining surplus. If the infringement is enjoined very early, then the infringer has sunk only a small part of his costs, and the infringer has a holdup power over the market opportunity, just as if infringement were deterred entirely. On the other hand, if the patentholder can delay substantially before enjoining infringement, he will wait until the infringer has sunk a large portion of his costs, and this improves his bargaining position. Consequently, the efficacy of the property rule depends critically on how the legal doctrines of laches and declaratory judgment are applied. The situation can be reversed when there is an alternative to the research tool. In that case, delay reduces the bargaining surplus (the remaining cost advantage from the research tool). Consequently, the patentholder has an incentive to enjoin as early as possible and the doctrine of laches is no longer a binding constraint.

Our arguments lead us to the conclusion that the best liability rule depends both on the context (the best rule for owners of research tools can be different from the best rule for owners of other proprietary products), and on whether infringement would be deterred under the doctrine of unjust enrichment. We do not wish to sidestep the latter issue, but rather to emphasize it as one of our main conclusions. Every scholar who contemplates damages will confront the same realization.

We have compared existing liability and property rules, rather than deriving an optimal enforcement scheme. However, the analysis provides lessons for both optimal damage awards and for the property rule. First and most important, for research tools, optimal damages should be just low enough not to deter infringement in the absence of a license, and high enough to transfer most of the infringer's profit to the patentholder. Under our assumptions of complete information and frictionless bargaining, such a transfer increases the incentives to develop research tools without impeding their efficient use. The second lesson, for an optimal property rule, involves the timing of injunctions. The doctrines of laches and declaratory judgment strongly affect the division of profit, and they should be treated as policy instruments.

There are three important extensions to this line of research. The first is to introduce imperfect bargaining into the analysis. We have focused on how different liability and property rules affect the *ex ante* incentives to develop research tools, assuming that efficient bargaining takes place. Most of the earlier literature focuses on the consequences of bargaining failures. Future work will need to bridge this gap, at the same time recognizing that the extent of bargaining failure itself is endogenous and may be affected by the liability or property rules. The second extension, as suggested in Section 5, is to find reasonable hypotheses on bargaining when each application requires the use of many tools. The third extension is to introduce moral hazard on the part of the user of the research tool. In our analysis, the cost of developing the second-stage product is fixed and known. If the quality of the commercial product (or its completion date) is a function of the effort by the research tool user, then it will be efficient to have a division of the (endogenous) rents between the research tool owner and user.[10] Even with efficient *ex ante* bargaining, this could change the relative merits of the different liability and property regimes.

[10] For an analysis of patent protection in a model of cumulative innovation with moral hazard, see Denicolò (2000). He does not analyze infringement or bargaining in the shadow of liability and property rules.

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