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Publication Date

2000-07-01

Damages and Injunctions in Protecting Proprietary Research Tools¹

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revised June 2000

Abstract: We investigate how liability rules and property rules affect the incentives to invest in research tools. We argue that it is hard to deter infringement under any of the enforcement regimes available. However, counterintuitively, a credible threat of infringement can actually be beneficial to the patentholder. We compare the two doctrines of damages under the liability rule, namely, lost profit (lost royalty) and unjust enrichment, and argue that unjust enrichment protects the patentholder better than lost royalty. Both can be superior to a property rule (the right to enjoin infringement), depending on how much delay is permitted before infringement is enjoined. We also show that, for patents on end-user products, the ranking of liability doctrines is reversed: unjust enrichment is inferior to lost profits.

Keywords: intellectual property, damages, injunctions, research tools

JEL Classification: K0

¹We are grateful to the Sloan Foundation and National Science Foundation for financial support, and to the managers, scientists and lawyers in biotechnology firms who provided valuable information about the biotechnology industry and the legal context in which it operates. We thank two anonymous referees and the Editor for very constructive comments, Stephen Maurer for guidance on legal issues and other helpful comments, and also to Rebecca Eisenberg, Rob Merges, Lynn Pasahow, Jennifer Reinganum, Brian Wright, and participants at the NBER conference on The Patent System and Innovation (January 1999) and Institute of Economics, University of Copenhagen.

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1 Introduction

Many types of inventions can be proprietary: new products, new processes for producing products, and research tools for developing products. Research tools have particular prominence in modern industries such as biotechnology. 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 to become inactive.

Two aspects of research tools make enforcement of intellectual property rights particularly challenging. First, the profit will derive mainly from licensing, often as a pass-through from proprietary products that were developed using the tool. A main theme of this paper is that, where all the revenue comes from licensing, legal doctrines of liability can be unsatisfactory. Second, when the research tool has been used without license, the proprietary product itself might or might not be found to infringe the patent on the tool. Consider a drug based on a proprietary gene sequence, and suppose that the drug company used PCR in developing the drug. If the drug has chemical structure related to the gene sequence, it might infringe the patent on the sequence. However it might be difficult to argue that the drug also infringes the patent on PCR, since it might be difficult to prove that the tool was used in developing the product. This puts the owner of PCR in a more difficult position than the owner of the gene sequence, since infringement must be detected at the stage of development.

Our objective in this paper is to understand how damages and injunctions protect intellectual property on research tools. When a resulting proprietary product can be proved to infringe the tool, as in the example of the gene sequence, liability and damages are a feasible remedy to infringement. We will proceed as if this is the case, recognizing that otherwise (e.g., for PCR) the main remedy will have to be detection and injunction at the development stage.

We take the view that infringement will never occur in equilibrium. If infringement is truly tempting under an enforcement regime, then the firms will license to avoid it, especially when they can increase joint profit by licensing. 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.

But even if infringement will never occur in equilibrium, an important question for our analysis is whether infringement would be deterred, absent a license. The objective of enforcement is to deter infringement. We notice, however, that if all the enforcement regimes deterred infringement equally well, then they would be equivalent to the patentholder. Perhaps our most robust conclusion is that the enforcement regimes we study are not equivalent because they are not equally effective at deterring infringement.

A surprising realization is that deterrence might not be good for the patentholder, at least if he can collect damages ex post. Deterrence can undermine the patentholder's profit for the following reason. Ultimately both the patentholder's and the licensee's profit come from selling a proprietary product that the licensee (or infringer) will develop. 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 the license. Compare 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 them of the product.

Our analysis of damages thus revolves around whether the enforcement regime would deter infringement, absent a license. It has the odd twist that deterrence can be counterproductive. It also puts sharply into focus a nuance regarding damages. American law has recognized two doctrines: lost profits (or lost royalties) and unjust enrichment. Part of our objective is to compare them in terms of the rewards they generate for the patentholder on the research tool. We argue that infringement is not deterred under the lost-royalty doctrine, but that the deterrence effects of the unjust-enrichment doctrine are less clear. The unjust-enrichment doctrine requires that the infringer disgorge his unauthorized gains to the infringed patentholder. The infringer is therefore left with zero profit. But does the prospect of zero profit deter infringement? Either assumption is tenable, and we assume it does not. This is because there is some probability that an infringer either will not be detected or that he will not be held liable. For example, it might be difficult to muster evidence that

the infringer used the tool. However we explain in the conclusion how our results change if we take the opposite view.

If a proprietary product developed with a research tool will not be found to infringe, injunctions are an essential enforcement device. After the patentholder stops the unauthorized use of his tool, he will presumably negotiate a settlement with the infringer, so that the profitable product can go forward. The terms of the settlement will depend on how much cost the infringer has sunk before the injunction. We show that, if there is no alternative to the research tool, the patentholder would like to delay the settlement because delay improves his negotiating position. However, under the *doctrine of laches*, a long delay in asserting patent rights can nullify the rights. The allowable delay affects whether an infringement begins in the first place. We think of the allowable delay as a policy variable, in the sense that it determines the efficacy of injunctions as an enforcement device. We also show that if a higher-cost alternative to the proprietary research tool is available, the patentholder would like to enjoin as early as possible, so the doctrine of laches is not a binding constraint.

Our main conclusions are these:

- A wide array of damage measures may be consistent with the lost profit (lost royalty) doctrine of damages. This is due to a circularity in the doctrine. 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. These are self-confirming.⁴
- The measure of damages consistent with the doctrine of unjust enrichment is unique, and transfers more profit to the patentholder than the damage measures consistent with the lost-royalty doctrine.
- A right to enjoin infringement is more profitable to the patentholder than damages under the lost-royalty rule, even when both are available. However, in-

⁴Leitzel (1989) discusses a similar problem of circularity in the context of defining "reasonable" contract reliance damages. He proposes to avoid the circularity by defining reasonableness in terms of the socially efficient level of damages. But this approach does not save the reasonable royalty rule because this rule is explicitly based on the idea of a hypothetical negotiation between the two parties, the outcome of which will not generally coincide with the socially efficient level of damages. For a recent example of the circularity problem in the copyright fair use doctrine, see *A.G.U. v. Texaco*, 60 F.3d 913 (2d Cir. 1994).

junctions are not an improvement if they must be invoked “too soon” or “too late”.

- The doctrine of unjust enrichment is more profitable for the patent holder than either the lost-royalty doctrine or the right to enforce by injunction.

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 the *equilibrium* division of profit. 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 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 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 patent holders 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 paper 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 (firm 1) has developed a proprietary research tool which is needed to develop a commercial product.⁵ 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 suppose that multiple research tools are required for each proprietary product, and investigate damage remedies under the two situations that licenses are negotiated separately for each application, and that they are sold anonymously in a market. Anonymity undermines the conclusion that the tool will always be used efficiently.

In Section 6 we investigate whether our conclusions hold for other proprietary products that would naturally be licensed. We consider a proprietary product that the patentholder would like to license in order to reduce production costs. For such products, we reverse our conclusion on damages doctrines: lost profit is a better doctrine of damages than unjust enrichment.

⁵The model has the cumulative features of Scotchmer (1991), and Green and Scotchmer (1995), but we focus on different issues. They investigated the division of profit between sequential innovators, where the second innovation might or might not infringe the first patent. Implicitly assuming a property rule, they discussed how patent breadth (the probability of infringement) affects the terms of licensing. For research tools, *any* unauthorized use of the proprietary tool is an infringement.

2 Legal Doctrines: Damages and Injunctions

2.1 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 focussed 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 as to maintain his incentives to invest in R&D (*England v. Deere & Co.*, 221 F. Supp. 319, 1963). Prior to 1946, when the current statutory rules on damages took form, the courts appear to have given greater weight to unjust enrichment. During the post-war 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 used as late as the second world war (*Littlefield v Perry*, N.Y. 1875, 188 US 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.⁶

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

⁶For 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.

“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.⁷

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 paper 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 is logically consistent with it. In order to emphasize this circularity, we will refer to “lost royalty” instead of “reasonably royalty”.

2.2 Injunctions

Under a property rule, the patentholder can sue to enjoin an infringing use of the proprietary research tool. In the model below, we will 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. However, if there is a substitute for the research tool (for example, a 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

⁷Panduit 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.

infringer if he made significant investments during the period of delay.⁸ 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 non-infringement. A declaratory judgment suit is unlikely if the infringement can be hidden, or where 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.⁹

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 which implied that the patent would not be enforced, and if the defendant relied upon them and suffered injury as a result.¹⁰ Unlike laches, a defense of estoppel does not require unreasonable delay by the patent owner, and 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 typically begin about halfway in the development process. This sets a lower bound to the proportion of costs that the infringer has sunk before the patentholder can seek an injunction.

We know of no cases establishing when and whether the 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. Below we suppose that the patentholder can seek an injunction and ex post settlement if he detects infringement

⁸Rome 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.

⁹Jensen 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.

¹⁰See 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), Sec.282 and 286.

during development, but not afterwards. Even if there were a right to enjoin or collect damages afterwards, there is a serious evidentiary problem of establishing that the research tool was used.

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 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) in developing 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. 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.

The premise of our analysis is that it is desirable to transfer the entire profit surplus of the product to the owner of the research tool, where the *profit surplus* is $v - c$. Thus we focus on the question of how much profit surplus is transferred to the patentholder under the property and liability regimes. We assume that the parties will achieve *ex post* efficiency. Once the research tool is invented, the patentholder can only earn profit by licensing it to create new products. 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 forego his product, or develop it without authorization, and pay damages afterwards, say d . If he infringes under the property rule, he will be enjoined after paying some portion of his costs, and the firms will reach a settlement. Neither firm

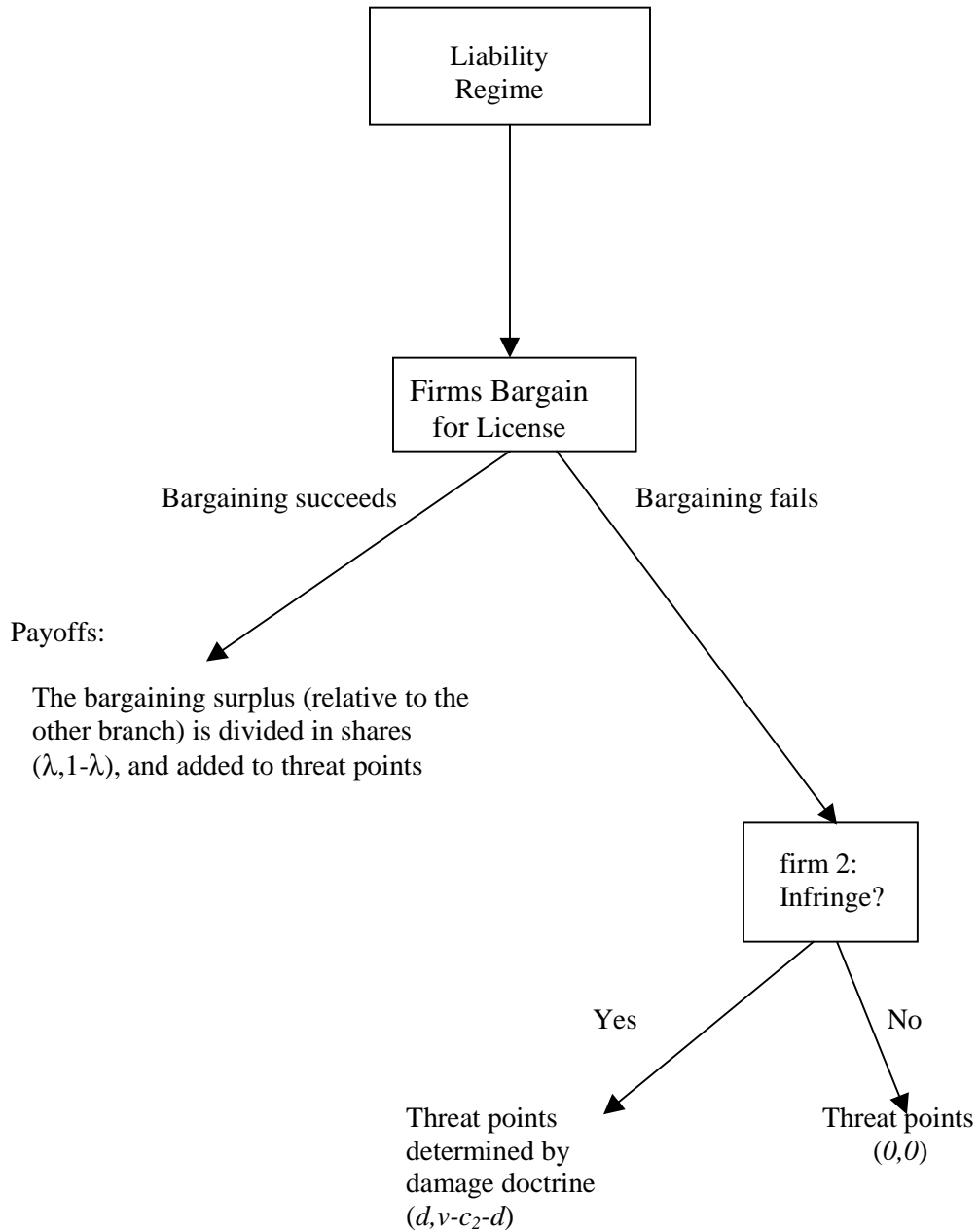


Figure 1: The Bargaining Game for a License

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 bargaining surplus is always shared according to $(\lambda, 1 - \lambda)$, $0 < \lambda < 1$. The order of moves is described in Figure 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.¹¹ However we assert in the hypothesis below that neither doctrine of damages deters infringement; that is, the damages d under each doctrine are low enough so that, absent a license, firm 2 would be willing to infringe the patent and pay damages.

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 in this situation:

Hypothesis on Damages: Damages and license fees (d, L) are consistent with the lost-royalty doctrine if and only if $d \in [0, v - c]$ and $d = L$. Damages and license fees (d, L) are consistent with the unjust-enrichment doctrine if and only if $d = L = v - c$.

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 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

¹¹One might conjecture that, if several firms are capable of developing the profitable market opportunity, the patentholder can avoid sharing profit by auctioning the right to use the patent. To some extent this is true, but, due to the patentability of the commercial product itself, the auction will not garner all of the profit for the patentholder. See Scotchmer (1996). One can think of λ as a parameter that goes as far in this direction as possible.

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 $v - c$. For the reason already articulated, $L = d$.

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 6 below.) The following Lemma follows immediately from the interpretations of the two liability rules.

Lemma 1 [Liability Regime] *Suppose that a single research tool is required to develop a proprietary commercial product. 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 $\pi^{UR} = v - c$.*

Thus, the unjust-enrichment doctrine does a better job of protecting the patentholder. The lost-royalty 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. However, 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 $(\lambda, 1 - \lambda)$. 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 interpret the relevant aspects the law to mean that there is some proportion of cost, say f , $0 < f < 1$, 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.¹² 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 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, say π^I , depends on f . The second part of the lemma says that the patentholder's profit is not monotonic in f .

Let

$$f^* = \max\left\{\frac{(v - c)(1 - \lambda)}{c}, 1\right\} \quad (1)$$

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*

(1) *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 ($f = 0$).*

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

Proof: (1) follows because equilibrium profits are $((\lambda(v - (1 - f)c), (1 - \lambda)(v - (1 - f)c) - fc)$. (2) 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 $\lambda(v - c)$. QED

Thus, despite point (1), the patentholder is better off if the doctrine of laches actually constrains him so that he cannot delay the injunction indefinitely. Without the

¹²If a declaratory judgment required $f \geq f_1$ and an injunction required $f \leq f_2$, then the binding constraint is $\min[f_1, f_2]$.

constraint, the patentee cannot commit not to 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 conclusions:

Proposition 1 [Liability versus Injunctions] *Suppose that a single proprietary research tool is required to develop a proprietary commercial product. The patentholder earns more profit under a liability regime with unjust-enrichment than under a liability regime with lost-royalty or under a property rule.*

The effectiveness of the property rule in transferring the surplus depends on when the doctrine of laches takes effect, as modeled in the parameter f . Like the lost-royalty rule, the property rule is an unreliable vehicle for enforcement unless the laches parameter is set efficiently at f^* . When $f^* < 1$, it has an interesting interpretation: it is proportional to the rate of return on investment, $\frac{v-c}{c}$, where the factor of proportionality $\frac{1-\lambda}{\lambda}$ decreases with the patentholder's bargaining power λ .

Remark 1 *To achieve maximum profit for the patentholder, the doctrine of laches should take effect sooner when products are more 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 instead. It would be in the interest of one party or the other to force the damage payment instead of a negotiation. Thus the threat of injunction does not change what would happen under the liability rule for research tools.

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 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 initial patent makes it more difficult to develop a close imitation. The *social 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 on Damages: Damages and license fees (d, L) are consistent with the lost-royalty doctrine if and only if $d \in [0, \sigma - c]$ and $d = L$. Damages and license fees (d, L) are consistent with the unjust-enrichment doctrine if and only if $d = L = \sigma - c$.

The reasoning is exactly as in Section 3, except that the maximum damages are $\sigma - c$ rather than $v - c$. It follows almost immediately, as in Section 3, that the doctrine of unjust enrichment is typically more profitable for the patentholder than the lost-royalty doctrine, although not as profitable as when no substitute is available. Under the lost-royalty doctrine, the patentholder earns profit anywhere in the interval $[0, \sigma - c]$, whereas under the unjust-enrichment doctrine, he earns profit equal to $\sigma - c$.

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, the bargaining surplus is declining as time passes because the bargaining surplus consists of the costs that can be saved by using the proprietary tool rather than the substitute. Thus, if a fraction f of the development has already occurred when the infringement is enjoined, the remaining bargaining surplus is $(1 - f)(\sigma - c)$. Our conclusions about the firms' preferences for delay are consequently reversed. The patentholder prefers to enjoin immediately, whereas the infringer prefers to delay indefinitely. If the patentholder enjoins immediately, he gets profit $\lambda(\sigma - c)$, and if he

delays longer, he gets less. Thus the doctrine of laches is not a binding constraint in this case. Consequently:

Proposition 2 [Liability and Injunctions] *Suppose that a commercial product can be developed either with a proprietary research tool or with a noninfringing substitute, but at greater cost. The patentholder earns more profit under the doctrine of unjust-enrichment than he would earn under the doctrine of lost royalty, and more than he would earn under a property regime where he can enjoy infringement. The research tool will be used in equilibrium under all three enforcement regimes.*

Remark 2 *We have assumed that none of the development costs are "specific" to the use of the proprietary research tool. Suppose instead that fraction α of the development costs must be incurred again if firm 2 switches to the alternative tool. Then the bargaining surplus at the time of the injunction f is $(1-f)(\sigma-c)+\alpha fc$. The first term is the remaining benefit from using the tool. The second term represents the switching cost, which is a "hold-up" value for the patentholder. Since firm 1's threat point is zero (it cannot develop the commercial product), its profits from ex post settlement are $\lambda\{(1-f)(\sigma-c)+\alpha fc\}$, which are decreasing in f when $\alpha \leq (\sigma-c)/c$. Thus the patentholder prefers to enjoin immediately provided that the cost saving from the research tool is larger than the "specific" development costs.*

5 Licensing Several Tools

We now investigate the relative merits of lost royalty and unjust enrichment when many research tools are required for the commercial product, rather than only one. For the moment we maintain our hypothesis that the market for licenses is "nonanonymous." The user negotiates with each tool owner, and we assume that the value v of the proprietary product is publicly observable. Afterwards we consider anonymous licensing, as might be appropriate when the values of the proprietary products are not unobservable.

Suppose that there are N tools, indexed $i = 1, \dots, N$, 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 license fees will be $\{L_i\}_{i=1}^N$. The fact that each tool is licensed to many users gives a basis for the following hypothesis, which is analogous to the one above.

Hypothesis on Damages when Tools are Licensed Nonanonymously: Any license fees and nonnegative damages $\{L_j\}_{j=1}^N, \{d_j\}_{j=1}^N$, are consistent with the lost-royalties doctrine, provided $d_j = L_j, j = 1, \dots, N$, and $v - \sum_{j=1}^N L_j - c \geq 0$. Any license fees and nonnegative damages $\{L_j\}_{j=1}^N, \{d_j\}_{j=1}^N$ are consistent with the unjust-enrichment doctrine, provided $d_j = L_j, j = 1, \dots, N$, and $v - \sum_{j=1}^N L_j - c = 0$.

The hypothesis regarding lost royalties 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 not only as regards the division of profit 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”. Hence $v - \sum_{j=1}^N L_j - c = v - \sum_{j=1}^N d_j - c \geq 0$

Under the doctrine of unjust enrichment, damages will exhaust the net profit, hence the license fees must exhaust the net profit. This is not true of the lost-royalty doctrine, for the same reason as in the previous section with only one research tool.

Lemma 3 [Liability Regime with Nonanonymous Licensing] *Suppose that several research tools are required to develop a proprietary commercial product. Suppose that the market for research tools is nonanonymous, so that licensors and licensees bargain for user-specific license fees. Then*

(1) *Under the lost-royalty doctrine of damages, there are multiple equilibria with different license fees, and the equilibrium license fees will not necessarily exhaust social surplus. That is, $v - c \geq \sum_{j=1}^N L_j$, with possible inequality.*

(2) *Under the unjust-enrichment doctrine of damages, license fees exhaust the surplus: $v - c = \sum_{j=1}^N L_j$. Under both doctrines, investment will be efficient.*

The difference between anonymous and nonanonymous licensing is that, with anonymous pricing, there is a market by which to evaluate lost royalties. Anonymous

pricing means 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-royalty doctrine, but vanishes with the unjust-enrichment doctrine. Unjust enrichment of necessity refers to the infringer's specific circumstances, in particular, v , and not just to an anonymous market. We make the following hypothesis when tools are licensed anonymously in markets with common prices.

Hypothesis on Damages when Tools are Licensed Anonymously: Any license fees and nonnegative damages $\{L_j\}_{j=1}^N, \{d_j\}_{j=1}^N$ are consistent with the lost-royalties doctrine, provided $d_j = L_j, j = 1, \dots, N$, and the tools are sold at the license prices $\{L_j\}_{j=1}^N$ to other users. Any license fees and nonnegative damages $\{L_j\}_{j=1}^N, \{d_j\}_{j=1}^N$ are consistent with the unjust-enrichment doctrine, provided $d_j = L_j, j = 1, \dots, N$, and $v - \sum_{j=1}^N L_j - c = 0$.

We have made an important change to the hypothesis, relative to the nonanonymous case. We do *not* assume that under the lost-royalty doctrine, $v - \sum_{j=1}^N L_j - c \geq 0$. If an infringer has a project with positive but relatively low net value, $v - c$, he might be dissuaded from investing if the license fees are too high, because the court could reasonably assess lost royalty by looking at the royalty (or other license 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.

Lemma 4 [Liability Regime with Anonymous Licensing] *Suppose that several research tools are required to develop a commercial product. Suppose that the market for research tools is anonymous, so that all users pay the same license fee for each tool. Then*

(1) *Under the lost-royalty doctrine of damages, investment might not be efficient. There are multiple equilibria with different license fees, and license fees will not necessarily exhaust the surplus: $v - c \geq \sum_{j=1}^N L_j$, with possible inequality.*

(2) *Under the unjust-enrichment doctrine of damages, investment will be efficient, and equilibrium license fees exhaust the surplus: $v - c = \sum_{j=1}^N L_j$.*

Finally we ask how damages compare to injunctions. Since injunctions lead to settle-

ment, injunctions automatically undermine the anonymity of the market. In order to investigate injunctions, we must have an hypothesis about how the bargaining surplus is split at settlement, and whether an infringer will infringe all tools simultaneously or only one. The latter depends on how his share of the bargaining surplus shifts when there are more claimants. For simplicity we shall assume that the user will either be a legitimate licensee, or that he will infringe all tools simultaneously. As before, the possibility of infringement and settlement sets the threat points for license fees.

As before, we assume that the various competing legal doctrines combine so that settlement occurs after a proportion f of the cost has been sunk, $0 < f \leq 1$. To make the problem tractable, assume that all the licensors license at the same price L , and that there are n licensors. With infringement, injunction and settlement, the infringer's profit would be $(1 - \lambda)(v - (1 - f)c) - fc$. The profit would be negative if $f > f^*$, where f^* is defined in (1). If $f > f^*$, the potential licensor's "threat point" for a licensing negotiation is zero, and his equilibrium profit is $(1 - \lambda)(v - c)$. We have the same lemma as Lemma 2, except that we must substitute "the joint licensors" for "the patentholder", and $\sum_{j=1}^N L_j$ for the patentholder's profit π^I .

Finally we can compare the relative merits of the lost-royalty doctrine, the unjust-enrichment doctrine, and the property rule. When licensing is nonanonymous, we have a comparison that is very similar to the case of one tool in the previous section. When licensing is anonymous, the lost-royalty doctrine has a pernicious side effect that can be remedied by the unjust enrichment doctrine or a property regime, namely, that investment might not be efficient.

Proposition 3 [Comparison of Liability and Property Rules with Nonanonymous Bargaining] *With nonanonymous bargaining for licenses, the licensors' joint profit will equal the social surplus $v-c$ under the unjust-enrichment doctrine, but may be smaller under the lost-royalty doctrine. In both cases investment will be efficient. The equilibrium profit of licensors is greater under the unjust-enrichment doctrine than under either the lost-royalty doctrine or the property rule.*

Proposition 4 [Comparison of Liability and Property Rules with Anonymous License Fees] *With anonymous pricing of licenses, the licensors' profit will equal the social surplus $v-c$ under the unjust-enrichment doctrine, but may be smaller under*

the lost-royalty doctrine. Under the unjust-enrichment doctrine, but not necessarily under the lost-royalty doctrine, investments will be efficient. The equilibrium profit of licensors is greater under the unjust enrichment doctrine than under either the lost-royalty doctrine or the property rule.

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.

This line of reasoning is overturned in the case of anonymous pricing of licenses. Under the lost-royalty doctrine, license fees can be so high that both infringement and licensing would be deterred, to the detriment of all parties. An advantage of the unjust-enrichment doctrine is that it undermines the anonymity, and implicitly encourages the 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 complexities that arise from an inability of the potential infringer to communicate his net value $v - c$ credibly in this negotiation.)

6 Licensing Proprietary Products

We now investigate whether the above conclusions apply in all contexts where licensing is the natural use of intellectual property, or whether our conclusions are specific to research tools. To do this we consider proprietary products that are sold directly to end users, but assume that there is an efficiency reason to license, e.g., in order to reduce production costs. Our objective is again to understand which damage rule generates more profit for the patentholder in equilibrium. We do not discuss injunctions, as they play a different role for proprietary products than for research tools. Typically an infringer would be enjoined from selling the product, and damages would be collected for the period of infringement.¹³ We simply assume that the period of infringement is given.

¹³See Lanjouw and Lerner (1996) for an analysis of preliminary injunctions.

As before, we assume that the patentholder and potential infringer will bargain for a license. If no license is agreed upon, then infringement might occur, followed by a damage award, d . Whether there will be infringement depends on the prospective damages, and this prospect sets the threat points for licensing, as before. Our main conclusion about the relative merits of the lost-profits doctrine and unjust-enrichment doctrine is reversed in the case of stand-alone products.

Suppose that a proprietary invention opens a new market, and that the monopoly profit with the patentholder as sole supplier is π^M . Assume that if an infringer enters the market, the two firms will act as oligopolists, each earning profit π^O , where $2\pi^O < \pi^M$. Assume further that productive efficiency might require licensing, e.g., because the marginal cost of production is increasing in each firm. Let π^J be the maximum joint profit that the patentholder and potential entrant can earn if they produce efficiently and maximize joint profit, e.g., by agreeing to high royalties. Then $2\pi^O < \pi^M \leq \pi^J$. If $\pi^M < \pi^J$, then licensing should occur in equilibrium, since licensing allows an efficiency gain. The joint profit can be shared with complete flexibility through a lump sum transfer. As with research tools, licensing complicates the counterfactual notion of lost profit, and leads to a circularity in the measurement of damages under the lost-profit rule, as we now discuss. However, since lost profit includes profit on lost sales as well as lost licensing revenues, it is no longer true that a large multiplicity of damage measures are consistent with the lost profits doctrine.

To contemplate lost profit (royalty), one must ask what would have happened without the infringement, which in this case includes licensing. Our objective is to characterize the damages and profits that could be consistent with the lost-profits measure of damages and the unjust-enrichment measure of damages, and to illuminate which rule is more profitable for the patentholder in equilibrium.

We take lost profit to be the difference between the profits that the patentholder would have had in equilibrium, including licensing revenues and profit on his own sales, and the profit he gets in the oligopoly with infringement. As before, unjust enrichment is the profit that the infringer earns if he infringes without being punished.

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-profits and unjust-enrichment doctrines, respectively. 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 $\pi^J - \pi^{LP}$ under the two rules respectively. We again assume that if there is a bargaining surplus to share, the shares are $(\lambda, 1 - \lambda)$. The potential licensee's threat point will be zero under both damage doctrines.

Lemma 5 [Lost-Profit Doctrine] *Damages d^{LP} are consistent with the lost-profits doctrine if and only if $d^{LP} = \pi^M + \lambda(\pi^J - \pi^M) - \pi^O$. This deters infringement. The patentholder's equilibrium profit under the lost-profits doctrine is $\pi^{LP} = \pi^M + \lambda(\pi^J - \pi^M)$.*

Proof: Since d^{LP} equals the profits lost due to infringement,

$$d^{LP} = \pi^{LP} - \pi^O \tag{2}$$

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

$$\pi^{LP} = \pi^O + d^{LP} + \lambda(\pi^J - 2\pi^O) \text{ if } \pi^O - d^{LP} \geq 0 \tag{3}$$

$$\pi^{LP} = \pi^M + \lambda(\pi^J - \pi^M) \text{ if } \pi^O - d^{LP} < 0 \tag{4}$$

However (3) is inconsistent with (2), so damages cannot satisfy $\pi^O - d^{LP} \geq 0$, and the patentholder's equilibrium profit satisfies (4). (2) and (4) imply that $d^{LP} = \pi^M + \lambda(\pi^J - \pi^M) - \pi^O$. Since $\pi^O - d^{LP} < 0$, infringement is deterred and the lemma follows. QED

Lemma 6 [Unjust Enrichment Doctrine] *Damages d^{UR} are consistent with the unjust-enrichment doctrine if and only if $d^{UR} = \pi^O$, and the patentholder's equilibrium profit is $\pi^{UR} = 2\pi^O + \lambda(\pi^J - 2\pi^O)$.*

Proof: Damages under the unjust-enrichment doctrine are

$$d^{UR} = \pi^O \tag{5}$$

Since the threat points for the licensing agreement are $(2\pi^O, 0)$, and the bargaining surplus is $\pi^J - \pi^M$, the following must hold:

$$\pi^{UR} = 2\pi^O + \lambda(\pi^J - 2\pi^O) \tag{6}$$

QED

Proposition 5 [Comparison of Damage Doctrines] *Suppose that the owner of a proprietary product wants to license some of the production to another firm for efficiency. The other firm could alternatively infringe and pay damages. The patentholder's equilibrium profits are greater under the lost-royalty doctrine than under the unjust-enrichment doctrine.*

The lost-royalty doctrine will deter infringement, but the unjust-enrichment doctrine leaves an infringer with zero profit. We have assumed, perhaps with too much confidence, that with zero profit the infringer would be willing to infringe. This gives the potential infringer a threat to hold up the patentholder for some of the profit gain that is available by avoiding competition, and undermines the patentholder's profit. If the potential infringer were deterred, there would be no difference in equilibrium profits between the two rules.

7 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-royalty 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 judgement are applied. The situation is 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 conclude that a liability rule under the doctrine of unjust enrichment is best for protecting the owner of a research tool. However it is worth reiterating the most important assumption that underlies this conclusion. With the unjust-enrichment rule in place, we have assumed that, absent a license, the potential infringer would infringe the patent and develop the profitable market opportunity. If we assumed instead that infringement would be deterred, the unjust-enrichment rule loses its advantage. In that case, the unjust-enrichment rule might or might not be more profitable to the patentholder than the lost-royalty rule,¹⁴ and it is unambiguously inferior to a property rule.¹⁵

The knife-edge issue of whether the unjust-enrichment doctrine deters infringement is therefore central to our assessment. We do not wish to sidestep this issue, but rather

¹⁴If infringement is deterred, the bargaining surplus is $v - c$, and the patentholder's bargaining share is $\lambda(v - c)$. This can be larger or smaller than the damages $d \in [0, v - c]$ that are consistent with the lost-royalty rule.

¹⁵The patentholder's profit is $\lambda(v - c)$ under the unjust-enrichment doctrine, and $\lambda(v - (1 - f)c)$, which is the settlement after injunction under the property rule.

to emphasize it as one of our main conclusions. Every scholar who contemplates damages will confront the same realization.

We have carried out three robustness checks on our conclusions. First, we investigated whether they hold up when each licensee must license several research tools. If such licensing is nonanonymous, the same conclusions hold up. If licensing is anonymous, the anonymity of licensing can inhibit (the first-best) efficient use of the research tools.

Second, we investigated whether the same conclusions hold up in all contexts where the natural use of intellectual property is to license it. In particular, we also investigated the protection of patents on proprietary products that the patentholder would like to license in order to achieve efficiency in production. Perhaps surprisingly, we reversed our conclusion about the relative attractiveness of the two damage doctrines. Damages are unique under both doctrines, and infringement is unambiguously deterred under the lost-royalty doctrine. If infringement would also be deterred under the unjust-enrichment doctrine, then there would be no difference in equilibrium profits between the two doctrines. But if infringement would not be deterred under the unjust-enrichment doctrine, as we have assumed, then the unjust-enrichment doctrine is inferior to the lost-profit doctrine. Even if the infringer must give the patentholder all his profit *ex post* as damages, both firms suffer from competition during the infringement. The potential leakage of profit becomes a bargaining surplus in the licensing negotiation. It creates a holdup right for the prospective infringer that is not present in the case of research tools. Consequently deterrence looks relatively more attractive.

Third, we investigate the degree to which our conclusions change when the owner of the research tool himself has the capability to develop the profitable product, perhaps less efficiently. This analysis is in the appendix.

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, optimal damages should not deter infringement in the absence of a license, when the efficient use of the tool is to license it. Our objective is to transfer as much of the profit surplus as possible to the owner of the research tool, since, under our assumptions of complete

information and frictionless bargaining, such a transfer increases the incentives to develop research tools without impeding efficient use of the tools. To maximize the patentholder's profit, damages should be low enough not to deter infringement, but high enough to transfer most of the surplus to the patentholder. This is a fine line to walk.

The lesson for the 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 two 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, while 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 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.¹⁶ Even with efficient *ex ante* bargaining, this could change the relative merits of the different liability and property regimes.

¹⁶For an analysis of patent protection in a model of cumulative innovation with moral hazard, see Denicolo (forthcoming). He does not analyse infringement or bargaining in the shadow of liability and property rules.

Appendix:

Racing for the Commercial Product

We analyze the liability and property regimes for the case where both the patentholder and the potential infringer are capable of developing the commercial product at known costs c_1 and c_2 , respectively, and $v > \max\{c_1, c_2\}$. This raises two additional efficiency issues: first, development should be undertaken by the lower-cost firm, and second, a race should be avoided since it duplicates costs. The full surplus that is desirable to transfer to the patentholder is $\max\{v - c_1, v - c_2\}$. If the firms race, we assume that firm 1 wins with probability p , which could depend on (c_1, c_2) , although we suppress the notation. In the liability regime, firm 2 pays damages if it infringes and wins the race, but not otherwise. (An alternative assumption would be that firm 2 pays damage for infringing whether or not he wins the race. This alternative would not change the qualitative conclusions.)

A patent race raises two new issues. The first is how to interpret the lost-profit/reasonable-royalty doctrine. Whether the measure of damages is lost profit or lost royalty should depend on what action the patentholder would have taken, absent the infringement. If he would have worked the patent himself, we assume it is lost profit. If he would have licensed, we assume it lost royalty (as in the text). The counterfactual is difficult for the courts to discern in practice, but since our model has complete information, we stylize the choice as depending on the relative costs. If the patentholder is more efficient at developing the commercial product than the infringer ($c_1 \leq c_2$), we use lost profit. If the infringer is more efficient (e.g., when the owner of the research tool is a university), we use lost royalty.

The second issue is whether to define lost profit or unjust enrichment as an *ex post* realized value or as an *ex ante* expected value. These differ if the patentholder would race against the infringer to develop the proprietary product. An *ex ante* measure reflects the probability that the infringer would win the patent race. We can think of many criticisms, but since advocates might find it useful to argue in favor of measuring damages as an *ex ante* expected loss, we analyze that case to show that it does not change the qualitative conclusions.

In the text we made reasonable hypotheses on how the two damage rules, lost profit

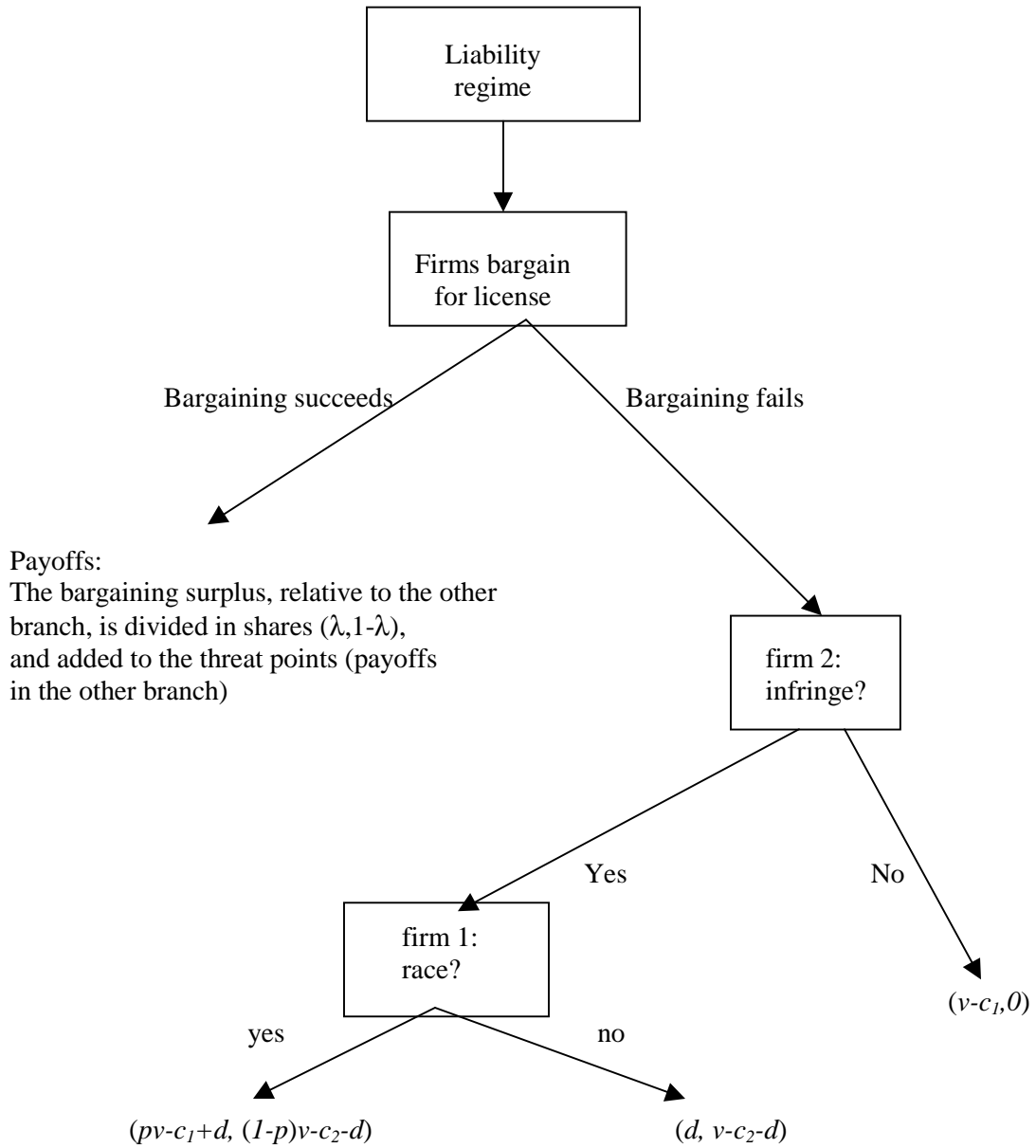


Figure 2: Bargaining for a license, when infringement might lead to a race.

and unjust enrichment, would be interpreted when there is no potential for a race. Now there are four rules, corresponding to whether the calculation is *ex ante* or *ex post*, as well as to whether the rule is lost profit (royalty) or unjust enrichment. The *ex ante* measure of damages depends on whether firm 1 would find it profitable to race against the infringer rather than to stay out of the race and collect damages *ex post*. If firm 1 would not find it profitable to race against the infringer, then the *ex ante* and *ex post* measures of damages coincide.

Figure 2 shows the order of moves in defining damages and establishing an *ex ante* license.

Lemma 7 [Liability Rule: Lost Profits] *Suppose that $c_1 \leq c_2$. When damages are calculated under either the *ex ante* or *ex post* interpretation of lost-profit, the patentholder collects the full surplus of the commercial product in equilibrium, and investment is efficient.*

Proof: Under the *ex post* measure of damages, the patentholder's lost profit is $d = (v - c_1) - (-c_1) = v$. If firm 2 must disgorge $d = v$ after investing, he is deterred from infringement. Thus firm 1 invests in equilibrium and earns the full surplus $v - c_1$.

Now consider an *ex ante* measure of damages. If the patentholder would race against the infringer, his *ex ante* loss in expected profit due to the infringement is $d = (v - c_1) - (pv - c_1) = (1 - p)v$. The infringer's expected profit is $(1 - p)v - d - c_2 = -c_2$. Thus, for parameter values such that the patentholder would race against the infringer, the damages calculated as an *ex ante* expected loss under the lost-profit rule are sufficient to deter infringement in equilibrium. For parameter values such that the patentholder would not race against the infringer, then the measure of damages is $d = v - c_1$, which also deters infringement. Since infringement is deterred, firm 1 is free to invest on his own, as is efficient. QED

Thus, under the lost-profit rule, if the patentholder is more efficient than the potential infringer at working the patent, the outcome will be as if the potential infringer was not present. Firm 1 will collect all the surplus. This is a case in which efficiency is served by deterring infringement. Our arguments in the text for why it might be suboptimal to deter infringement, absent a license, apply when investment should efficiently be delegated to firm 2.

Next suppose that $c_2 < c_1$, so that it is efficient for firm 2 to invest rather than the patentholder. We want to describe license fees and damages, (L, d) , that are consistent with the lost-royalty doctrine.

Lemma 8 [Liability Rule: Lost Royalty] *Suppose that $c_2 < c_1$. Any license fees $L \in \max\{\frac{pv-(1-\lambda)c_1}{p(2-p)}, 0\} \cup (\max\{\frac{pv-c_1}{p(2-p)}, 0\}, v - c_2)$ are consistent with the ex ante interpretation of lost-royalty. Any license fees $L \in \max\{\frac{pv-(1-\lambda)c_1}{p}, 0\} \cup (\max\{\frac{pv-c_1}{p}, 0\}, v - c_2)$ are consistent with the ex post interpretation of lost royalty. The patentholder does not necessarily collect the full surplus in equilibrium under either interpretation, but investment is efficient.*

Proof: Under the ex post interpretation of lost royalty, damages satisfy $d = L$. If the patentholder would not race against the infringer, then $d = L$ also under the ex ante interpretation of lost royalty. If the patentholder would race against the infringer, then the ex ante expected lost royalty is $\hat{d} = (1 - p)L$.

License fees must satisfy $L \leq v - c_2$, since firm 2 would not accept higher license fees.

Consider first the ex ante interpretation of lost royalty. If $L > \frac{(pv-c_1)}{p(2-p)}$, then firm 1 would not race against an infringer. Firm 1's expected profit in the race would be $pv - c_1 + (1 - p)\hat{d} = pv - c_1 + (1 - p)^2L$, and firm 1's expected profit if it stays out of the race would be L , which is larger when $L > \frac{(pv-c_1)}{p(2-p)}$. Thus any $L \in (\frac{(pv-c_1)}{p(2-p)}, v - c_2)$ is consistent with the doctrine of lost royalty, and infringement will not induce a patent race.

On the other hand, if $L < \frac{(pv-c_1)}{p(2-p)}$, firm 1 would race against the infringer, earning expected profit $pv - c_1 + (1 - p)^2L$. The prospect of this inefficient race sets the threat points for licensing to avoid the duplicated cost c_1 . Firm 1's equilibrium profit in a licensing agreement would be $pv - c_1 + (1 - p)^2L + \lambda c_1$. The equilibrium profit is achieved by simply collecting the license fee L in equilibrium, so the following must hold:

$$pv - c_1 + (1 - p)^2L + \lambda c_1 = L$$

The solution satisfies $L = \frac{pv - (1-\lambda)c_1}{p(2-p)}$, and this is the only license fee smaller than $\frac{(pv - c_1)}{p(2-p)}$ that is consistent with the ex ante interpretation of lost royalty.

Now consider the ex post interpretation of lost royalty, $d = L$. Firm 1 would race against an infringer if and only if $pv - c_1 + (1-p)L > L$, which occurs when $(v - \frac{c_1}{p}) > L$. However the firms will be better off licensing to share the saved cost c_1 . Firm 1's profit in this license agreement is $pv - (1-\lambda)c_1 + (1-p)L$. But in equilibrium this profit is achieved through licensing, in the shadow of infringement. Hence

$$pv - (1-\lambda)c_1 + (1-p)L = L$$

which has solution $L = \frac{pv - (1-\lambda)c_1}{p}$. This is the only license fee smaller than $(v - \frac{c_1}{p})$ that is consistent with the ex post interpretation of lost royalty. However any $L \in (\max\{0, \frac{pv - c_1}{p}\}, v - c_2)$ will also suffice. QED

Lemma 8 echoes the finding in the text, where the patentholder was not in a position to develop the commercial product. Namely, there is a circularity in defining damages as lost royalties. The circularity permits damages and license fees that do not transfer all the surplus to the patentholder.

Lemma 9 [Liability Rule: Unjust Enrichment] *When damages are calculated under either the ex ante or ex post interpretation of unjust enrichment, investment will be efficient, but the patentholder might not earn the full surplus when $c_1 \leq c_2$. Otherwise he earns the full surplus.*

Proof: First consider the ex ante measure of damages, which is $d = (1-p)v - c_2$ if the patentholder would race against the infringer, and $d = v - c_2$ if the patentholder would not race. Under the ex ante interpretation of damages, firm 1 would never race against the infringer. His expected profit if he races is $pv - c_1 + (1-p)((1-p)v - c_2)$, and his expected profit if he does not race is $v - c_2$, which is larger.

Suppose that $c_1 < c_2$. Then the patentholder would not race against a potential infringer. We have assumed that the potential infringer would not be deterred, even though he makes zero profit after paying damages. Thus there is a surplus $c_2 - c_1$ to divide in a licensing agreement, and firm 2 thus makes positive profit $(1-\lambda)(c_2 - c_1)$.

Suppose that $c_1 \geq c_2$. Then the patentholder would not race against a potential infringer, and the potential infringer would make zero profit. This is both efficient and transfers all the profit surplus to the patentholder.

Now consider the ex post measure of damages. The ex post measure is always $v - c_2$. If $c_2 < c_1$, then firm 1 would not race against the infringer, and would collect the full surplus in equilibrium. If $c_2 \geq c_1$, then firm 1 might or might not race against the infringer, depending on the parameters, but in either case, firm 1 collects less than the full surplus, since there will be an efficiency surplus to share with the infringer. QED

When firm 2 is the more efficient firm, this conclusion is the same as in the text. That is, firm 1 collects all the surplus. However when firm 1 is the more efficient firm, the lemma points out that the unjust-enrichment rule can give firm 2 a hold-up right. Even though firm 2 is the less efficient firm, he can threaten to invest, thus pre-empting firm 1, and firm 1 will “pay him off” not to do that.

The preceding three lemmas give us the following proposition:

Proposition 6 *If the patentholder is more efficient than firm 2 at developing the commercial product, then the patentholder will invest in the product. Under the lost profit rule the patentholder earns the full surplus in equilibrium, but under the unjust-enrichment rule, he might not. If the patentholder is less efficient than firm 2, then investment is efficient, and the patentholder earns the full surplus under the unjust enrichment rule, but not necessarily under the lost royalty rule.*

Now consider injunctions. Once firm 2 begins an infringing research program, the patentholder can either begin his own research program in parallel, or allow the infringement to continue until the injunction, when firm 2 has sunk fc_2 . If firm 2 would not begin an infringing research program, the patentholder will either develop the commercial product himself, or enter into an ex ante license with firm 2, in which case they share any efficiency gain $c_1 - c_2$ that firm 2 can offer.

Lemma 10 (Property Rule) *If the patentholder is the efficient firm in developing the commercial product ($c_1 \leq c_2$), he earns the full surplus under the property rule.*

If he is not the efficient firm ($c_1 > c_2$), his profit depends on the "laches" parameter f , and he earns profit in the interval $(v - c_1 + \lambda(c_1 - c_2), v - c_2)$.

Proof: Injunction and settlement occur after a proportion f of the infringer's cost has been sunk. At the time of injunction, the bargaining surplus is the difference between the patentholder's own cost and the remaining costs of the infringer, $c_1 - (1 - f)c_2$.

First consider f such that $c_1 - (1 - f)c_2 < 0$. There is no efficiency reason for the patentholder to strike a bargain rather than to invest on his own after the injunction. With no settlement, firm 2 will end up with profit $-fc_2$ and the patentholder will earn $v - c_1$. Anticipating this, firm 2 would never embark on an infringing research program, and the two firms will license ex ante. The threat points for this ex ante bargain are $(v - c_1, 0)$. The bargaining surplus is $\max\{c_1 - c_2, 0\}$. The firms split the surplus in shares $(\lambda, 1 - \lambda)$, earning $(v - c_1 + \lambda \max\{c_1 - c_2, 0\}, (1 - \lambda) \max\{c_1 - c_2, 0\})$. Thus the patentholder earns the full surplus if and only if he is the more efficient firm.

Now suppose that $c_1 - (1 - f)c_2 > 0$ and $c_1 \leq c_2$. We show again that firm 2 would never embark on an infringing research program. After injunction, the firms' threat points are $(v - c_1, -fc_2)$. At the time of injunction, it is more efficient for firm 2 to complete the product than for the patentholder to undertake it. The bargaining surplus is $c_1 - (1 - f)c_2$, and their equilibrium profits at settlement are $\pi_1 = v - c_1 + \lambda(c_1 - (1 - f)c_2)$ and $\pi_2 = -fc_2 + (1 - \lambda)(c_1 - (1 - f)c_2)$. However, $\pi_1 + \pi_2 = v - c_2$, so if $c_1 \leq c_2$, it holds that $\pi_2 < 0$ (using that $\pi_1 > v - c_1$). Anticipating negative profit, firm 2 will not embark on an infringing research program. In addition, there is no reason for an ex ante agreement. There is no efficiency surplus to split, since the patentholder is the more efficient firm. The patentholder thus earns the full surplus $v - c_1$.

Finally, suppose that $c_1 - (1 - f)c_2 > 0$ and $c_2 < c_1$. The patentholder earns π_1 at settlement, which is less than the full surplus $v - c_2$. The profit π_1 would also be his profit in an ex ante agreement, since there is no additional surplus to share. The patentholder only earns the full surplus at \hat{f} that solves $\lambda(c_1 - (1 - \hat{f})c_2) = c_1 - c_2$. If $f < \hat{f}$, the patentholder earns $\pi_1 < v - c_2$. If $f > \hat{f}$, infringement will be deterred, so the two firms will again be forced into an ex ante bargain in which they split the full surplus as $(v - c_1 + \lambda(c_1 - c_2), (1 - \lambda)(c_1 - c_2))$. The patentholder's profit is again less than the full surplus $v - c_2$. QED

We can now compare the liability regime with the property regime. These conclusions parallel those for the simpler case in the text, with one exception. Namely, the unjust enrichment rule may give a potential infringer a holdup power over a more efficient patentholder, which allows him to extract some of the profit.

Proposition 7 (Comparison of Liability Regime and Property Regime) *Under the liability regimes and the property rule, investment is efficient.*

(1) Under the unjust-enrichment rule, the patentholder earns the full surplus if the potential infringer is the more efficient firm, but not if he himself is the more efficient firm.

(2) Under the lost profit/reasonable royalty rule, it is the other way around. The patentholder earns the full surplus if he himself is the more efficient firm, but if the potential infringer is more efficient, the patentholder will typically earn less than the full surplus.

(3) Under the property rule, the patentholder earns the full surplus if he himself is the more efficient firm, but if the potential infringer is more efficient, he will typically earn less than the full surplus, depending on the "laches" parameter f .

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