Preliminary Injunctions and Damage Rules in Patent Law

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This paper shows that preliminary injunctions may be sought in patent cases to obtain market power during the period of the injunction and are likely to be sought only where there is a small probability that the patent will be ultimately found valid. Both patentee and alleged infringer benefit from a preliminary injunction. This is an artifact of the asymmetry of current damage rules. Altering the rules so that an innovator who wins a preliminary injunction on a patent ultimately declared invalid pays both lost profits to the imitator and a fine equal to lost consumer surplus creates efficient incentives.

1. Introduction

The number of patents granted in the United States surged from 49,000 in 1963 to 181,000 in 2004, with patents increasingly being sought in new areas, such as biotechnology, software, and business methods.[1] The burgeoning number of patents is leading unavoidably to more intellectual property disputes, with many firms treating patent litigation as an "expected expense."[2] As a consequence, the rules governing patent litigation are assuming increasing consequence. This paper studies the preliminary injunction, one of the key elements of patent litigation. The importance of preliminary injunctions is underlined by the finding that they were requested in about one-fifth of the patent cases in the sample collected by Lanjouw and Lerner (2001), and were granted

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1. US Patent and Trademark Office. See http://www.uspto.gov/web/offices/ac/ido/oeip/taf/h_counts.htm, last accessed August 22, 2006.

2. Robert Thompson, "Patents suits becoming common in tech industry," *Financial Post*, July 10, 2002, p. FP10.

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in about half of the cases that proceeded through to a ruling on the request.

A patent is granted when an innovator applies to the patent office with an innovation that is found to be new, useful, and nonobvious. The patent office is relatively generous in granting patents (see Lemley, 2001), but their validity or breadth may later be challenged in court by firms accused of infringement.[3] Patent cases are often complex, requiring specialized information on the part of the court, and they may involve very high stakes.[4] This leads to lengthy trials, which can extend for years (Anton and Yao, 2004; Aoki and Hu, 2003).

A patentee may move for a preliminary injunction at the beginning of a trial to enjoin an alleged infringer from using the innovation during the trial. Such an injunction protects the patentee's interests until the case is decided on the merits, as in the case of Amazon's celebrated patent on "one-click" purchasing.[5] Although a patent trial allows ample scope for discovery, testimony, and cross examination, the hearing for a preliminary injunction leaves the two sides having little time to prepare and present a case for or against an injunction (Budd, 1999). As a result, preliminary injunction proceedings are "fraught with the risk of error" either of the court enjoining a noninfringing firm or of not enjoining an infringing firm (Stein, 1997). Such errors may result in damages being paid: in the United States, the damages are calculated as the lost profits of the firm that was wrongly enjoined or the lost profits of the patentee who suffered infringement.

The damages rules applied in the US create incentives for patentees to apply for preliminary injunctions, and for imitators to acquiesce. The heart of the problem is that, although imitators receive damages when they are wrongly enjoined, consumers—who pay high prices while the preliminary injunction protects the monopoly—are

3. When a patent is filed, the patent clerk assigns the patent to one or more of the 120,000 US patent subclasses. These subclasses are then used by the patent office to search for whether the patent is adopting the prior art. With so many subclasses of patents, it is easy for the patent office to err by granting a patent that claims the prior art. See Lanjouw and Lerner (2001, 594, n. 32). Unless the prior art very clearly encompasses the patent, or there is no evidence of related prior art at all, the court will have to make a subjective decision as to whether the patent claims an innovation that would have been obvious to a person skilled in the art at the time the patent was filed.

4. In 1982, the US Congress created a specialized appellate court for patents. This court relaxed the criteria for the granting of preliminary injunctions to a "clear or strong showing" that the plaintiff would win the suit on the merits of the case, rather than showing "beyond question" that this would occur. See Lanjouw and Lerner (2001, p. 578).

5. Amazon received a preliminary injunction preventing other book sellers from using this system, but its patent was ultimately declared invalid. See *Amazon.com v. Barnesandnoble.com*, 73 F.Supp.2d 500 (1999).

uncompensated.[6] Thus, preliminary injunctions create extra profits to be shared between the firms in the industry. The patentee gets monopoly profits less a (possible) payment to the imitator; and the imitator obtains its expected profits without the risk of having to pay damages to the incumbent. The injunction can thus be seen as a court-ordered collusive scheme to charge monopoly prices and share profits. Ironically, as we show, the incentive to apply for an injunction is strongest when the probability of a finding of actual infringement is lowest.

There are four tests the court usually applies in a preliminary injunction hearing: (*i*) the plaintiff's likelihood of success on the merits; (*ii*) whether the plaintiff will suffer irreparable harm without the injunction; (*iii*) the balance of harms to the two parties; and (*iv*) the public interest. In practice, the plaintiff's likelihood of success on the merits of the case appears to be the most important criterion in the hearing (Cunningham, 1995; Martens and Conover, 1998; Lanjouw and Lerner, 2001, p. 578). The irreparable harm criterion leads to injunctions only when the harm to the patentee cannot be repaired financially.[7] If there is an apprehension that the imitator may not be financially able to pay damages, the court is at liberty to require a bond.[8] In any case, preliminary injunctions appear to be targeted at strong as well as financially weak defendants, implying that "the occurrence of 'irreparable harm' may not be that closely associated with defendants' financial resources" (Lanjouw and Lerner, 2001, p. 576). The balance of hardships criterion is unlikely to lead to preliminary injunctions so long as the damages fully compensate the party, which ultimately wins at trial. The public interest criterion has been characterized as a "make weight" (Wolf 1984, p. 224) and as a "wild card,"[9] although consumers would in general benefit from competition, contingent on innovation.[10]

6. This point is raised in the Canadian decision regarding a preliminary injunction in AstraZeneca Canada Inc. v. Minister of Health and Apotex, (2005 FCA 208), in which the court notes that both defendant and plaintiff can indemnify the other for damages, but that the case for "irreparable harm" to the public is more "compelling".

7. Sometimes irreparable harm is deemed to be present when the damages cannot be quantified clearly—for example, if the infringement might lead to a loss of key employees, or a change in market position. A recent court found that a strong showing of likelihood of success on the merits gives rise to a presumption of irreparable harm (Reebok Int'l. Ltd. v. J. Baker Inc., 32 F. 3d 1552 (1994)).

8. Flo-Con Systems, Inc. v. Leco Corp, 845 F. Supp 1576 (1993).

9. Lawson Prods., Inc. v. Avnet, Inc., 782 F. 2d 1429 at 1433 (1986).

10. In Eli Lilly & Co. v. Premo Pharmaceutical Laboratories, Inc., [630 F. 2d 120 (3d Cir.) cert. denied, 449 US 1014 (1980)] after determining that the patent had most likely been infringed, the court decided that the public interest factor favored granting a preliminary injunction, noting that "Congress has determined that it is better for the nation in the long-run to afford the inventors of novel, useful, and nonobvious products short-term monopolies on such products than it is to permit free competition in such goods" (p.138).

In *eBay*, the Supreme Court noted that the same four-fold test is applied in deciding whether to grant a permanent injunction.[11] Justice Kennedy, in a concurring opinion, observed that the "potential vagueness and suspect validity" of many patents—especially of those claiming business methods—may lead to a different weighting of the four factors. In some cases, as the Court noted, it may be inappropriate to grant a permanent injunction. Our paper suggests that in such cases the use of preliminary injunctions may be even more problematic.

Research on the economics of patents has focused principally on two areas—optimal patent policy, especially length and breadth (e.g., Nordhaus, 1969; Klemperer, 1990); and more recently the antitrust implications of patenting and licensing (e.g., Aoki and Hu, 1999; Lanjouw and Lerner, 2001; Shapiro, 2003).[12] This paper contributes to each of these areas. In terms of optimal patent policy, an important approach has been to acknowledge that patents are enforced only probabilistically (e.g., Katz and Shapiro, 1987; Aoki and Hu, 1999; Ayres and Klemperer, 1999; and Lemley and Shapiro, 2005). This is a key consideration because it affects the incentives for innovation and imitation. Our contribution is to explore how innovative and imitative behavior is affected by the probability of the innovator prevailing in a preliminary injunction hearing, and to propose a welfare-enhancing change in the rules according to which damages are awarded. In terms of antitrust analysis, our paper shows how patents and preliminary injunctions can be used to create inefficient market power without offsetting benefits.

Although there is extensive legal research on preliminary injunctions (e.g., Leubsdorf, 1978; Wolf, 1984; Cunningham, 1995; Stein, 1997; and Martens and Conover, 1998), the economics literature has only recently begun to recognize their importance. Lanjouw and Lerner (1996, 2001) examined evidence in 252 patent dispute cases and argued that preliminary injunctions are used to impose financial stress on weak rivals. In Lanjouw and Lerner (2001), the patentee does not know the *type* of the infringer. Thus, the infringer may refuse a settlement offer, forcing the game into the preliminary injunction stage. We show that even with only one type of infringer and common knowledge over payoffs, the patentee may wish to seek a preliminary injunction. The reason for this is that the possibility of obtaining a temporary monopoly through a preliminary injunction may be preferred to a licensing arrangement in which monopoly profits are dissipated, as in Lanjouw and Lerner (1996). Unlike Lanjouw and Lerner, who focus on litigation financing

11. eBay Inc. v. MercExchange, L.L.C., 126 S. Ct. 1837 (2006).

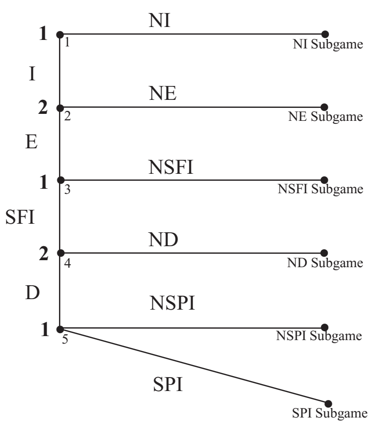
12. In an earlier version of this paper, we considered a form of *ex post* licensing, following Aoki and Hu (1999). The results of that analysis are not reported here, as the results were virtually identical to those in Aoki and Hu.

costs, we explicitly consider both the decision by a potential infringer to enter the market and the decision by a firm to innovate. Thus we find that preliminary injunctions not only affect welfare once a product has been developed, but also affect the decision to innovate. As in Shapiro (2003), we allow the infringer to avoid some potential future damages by limiting output if not enjoined through a preliminary injunction. In equilibrium, we find that this is exactly what the infringer does. Finally, we consider the properties of an alternative damage rule in which a patentee who obtains a preliminary injunction based on a patent ultimately found invalid at trial is made liable for lost consumer surplus as well as the lost profits of the alleged infringer.

The remainder of the paper is organized as follows. Section 2 describes the game. Section 3 solves the litigation subgame. Section 4 solves the entry and innovation subgame. Section 5 derives the welfare properties of the equilibria and proposes a simple damage rule to rectify the problems identified. Section 6 concludes.

2. Description of the Game

Figure 1 shows the game tree for the sequential game studied in this paper. The bolded numbers to the left of each decision node identify the player making a decision. The smaller numbers under the nodes identify the decision nodes. The strategies at each node are indicated in capital letters. Each "terminal" node corresponds to a further subgame



$$\pi_1^{NI} = 0$$
$$\pi_2^{NI} = 0$$

$$\pi_1^{NE} = (1+\beta)\pi^m - c_I$$
$$\pi_2^{NE} = 0$$

$$\pi_1^{NSFI} = (1+\beta)\pi^d - c_I$$
$$\pi_2^{NSFI} = (1+\beta)\pi^d - c_E$$

$$\pi_1^{ND} = (1+\beta)\pi^m - c_I$$
$$\pi_2^{ND} = -\, c_E$$

$$\pi_1^{NSPI} = \pi_1(\theta) + \theta(\beta\pi^m + D_1) + (1-\theta)\beta\pi^d - c_I - c_{L_1}$$
$$\pi_2^{NSPI} = \pi_2(\theta) + (1-\theta)\beta\pi^d - \theta D_1 - c_E - c_{L_2}$$

$$\pi_1^{SPI} = \phi[\pi^m + \theta\beta\pi^m + (1-\theta)(\beta\pi^d - D_2)] + (1-\phi)[\pi_1(\theta) + \theta(\beta\pi^m + D_1) + (1-\theta)\beta\pi^d] - c_I - c_{L_1}$$
$$\pi_2^{SPI} = (1-\phi)[\pi_2(\theta) + (1-\theta)\beta\pi^d - \theta D_1] + \phi(1-\theta)(\beta\pi^d + D_2) - c_E - c_{L_2}$$

FIGURE 1. PATENTS AND INJUNCTIONS GAME

in which a Nash quantity game occurs. The expected profits from the Nash quantity subgames are written to the right of each terminal node. Each player has common knowledge over both players' revenues and costs, and the probabilities that the court will uphold the patent and grant a preliminary injunction. Court actions appear only in the terminal subgames and are implicit in the expected profits expressions.

The game begins at node 1 when firm 1, while engaged in research, discovers a patentable idea. This idea can be developed into a patented innovation at cost $c_I > 0$, which is sunk once firm 1 innovates. Cost c_I includes the cost of developing the innovation and the expense of writing and submitting a patent application. The imitator, firm 2, cannot imitate unless firm 1 has innovated. Thus if firm 1 chooses not to innovate, both firms earn zero profits in the subgame *NI*.

We model the lifespan of the product in two parts: the duration of the litigation stage is normalized to one, so that for a product whose life is $T > 1$ periods, β is the relative weight on the present value of profits earned in the posttrial stage.[13] If firm 2 does not enter, then firm 1 earns monopoly profits, denoted as π^m, during the litigation stage and monopoly profits $\beta\pi^m$ in the posttrial stage. Thus, firm 1 earns profits of $(1 + \beta)\pi^m - c_I$ if firm 2 chooses not to enter, and firm 2 earns zero. These are the payoffs in the no entry subgame, *NE*.

If firm 2 enters, at cost c_E which is sunk upon entry, firm 1 may sue for infringement. Let θ denote the commonly known probability that firm 1 is successful at trial if it sues firm 2. Thus θ is the probability that the court will find the innovation sufficiently novel at trial to uphold the patent if challenged. If firm 2 enters (*E*) and firm 1 does not sue for infringement (*NSFI*), each firm earns symmetric duopoly profits, denoted as π^d. Thus profits are $(1 + \beta)\pi^d - c_I$ for firm 1 and $(1 + \beta)\pi^d - c_E$ for firm 2. We assume that $\pi^m > 2\pi^d$, so that competition decreases industry profits.

Once firm 1 decides to sue firm 2 for patent infringement (*SFI*), firm 2 may choose to either defend (*D*) or not defend (*ND*) itself against patent infringement. If firm 2 does not defend itself, there is no trial, and firm 1 earns monopoly profits less innovation costs, although firm 2's payoff is $-c_E$. Conversely, if firm 2 chooses to defend itself against patent infringement, three new elements come into play. First, firm 1 incurs litigation costs of c_{L_1} although firm 2 incurs litigation costs of c_{L_2}. Second, firm 1 may also seek to obtain a preliminary injunction (*SPI*) against firm 2 to prevent it from producing during the trial period. The probability

13. If profits are ν per instant in time, then the present value of cumulative profits is $\phi = \int_0^1 e^{-\rho\sigma}\nu d\sigma$ during the trial period and $\beta\pi = e^{-\rho}\int_1^T e^{-\rho\sigma}\nu d\sigma$ during the posttrial period. Therefore, $\beta = (e^{-\rho} - e^{-\rho T})/(e^{\rho} - 1)$. For a patent that lasts $T = 20$ years, β is approximately equal to 10 at an interest rate of $\rho = 0.05$.

that the court will grant a preliminary injunction is ϕ, which, like θ, is common knowledge between the firms. If a preliminary injunction is granted, firm 1 will earn monopoly profits during the period of the trial. If not, the firms compete. Third, one of the firms may face a liability for damages imposed on the other firm. If firm 1 either does not seek a preliminary injunction (*NSPI*) or seeks one without success, and its patent is upheld at trial, firm 2 faces liability for infringing on firm 1's patent during the period of the trial. Let D_1 denote the damages that firm 2 is liable to firm 1 in this case. Conversely, if firm 1 obtains a preliminary injunction, it faces a liability for the damages D_2 that firm 2 incurs through being enjoined during trial, in case the patent is found invalid.

Under US rules, the damages are not symmetric. If firm 2 is enjoined, the liability to firm 1 is simply $D_2 = \pi^d$, the foregone profits firm 2 would have earned had there been no patent. Firm 2's liability, on the other hand, depends upon how much it produces. If firm 2 is found to have infringed, the damages it must pay are the difference between firm 1's potential and actual earnings. Thus, firm 2 can limit its liability by restricting its output. As we show below, in the Nash equilibrium to the output game, both firm 2 and firm 1 have an incentive to alter their output relative to the duopoly equilibrium when firm 2 is facing potential damage claims. We let $\pi_1(\theta) \geq \pi^d$ and $\pi_2(\theta) \leq \pi^d$ denote firm 1's and firm 2's profits, respectively, during the trial period when firm 2 restricts its output in order to limit its liability. Thus, firm 2's potential liability is only $D_1 = \pi^m - \pi_1(\theta)$. In general, the functions $\pi_1(\theta)$ and $\pi_2(\theta)$ depend upon the form of the damage rules as well as the probability, θ, that firm 1 wins at trial.

Next, we analyze the litigation portion of the game using the damage rules described above. We return to the entry and innovation stages of the game in Section 4.

3. The Litigation Subgame

The litigation subgame begins at node 3 in Figure 1. Firm 1 has already patented an innovation (with sunk cost c_I), and firm 2 has entered (with sunk cost c_E). The choice faced by the innovator at node 3 is whether or not to sue for infringement. If it does not sue for infringement (*NSFI*), its gross profits are $(1 + \beta)\pi^d - c_I$. If it does sue for infringement, the entrant will keep an eye on its potential liability when choosing its output.

We begin by solving for the Nash equilibrium *output* by each firm given that firm 1 has chosen to sue for infringement and firm 2 has chosen to defend. This makes explicit the effects that changes in θ have on the damages firms incur, given that firm 2 can avoid damages by ceding market share to firm 1. We assume that each firm behaves as a Cournot duopolist. Thus if both firms produce during the trial period, their expected variable profits are

$$V_1 = P(Q)q_1 - c(q_1) + \theta\{\beta\pi^m + \pi^m - [P(Q)q_1 - c(q_1)]\} + (1-\theta)\beta\pi^d, \tag{1a}$$

$$V_2 = P(Q)q_2 - c(q_2) + (1-\theta)\beta\pi^d - \theta\{\pi^m - [P(Q)q_1 - c(q_1)]\}, \tag{1b}$$

where $Q = q_1 + q_2$ is total output, $P(Q)$ is the demand curve ($P' < 0$), and $c(q_i)$ is the cost function faced by each firm ($c' > 0$). The Nash equilibrium is the solution to the following:

$$\partial V_1/\partial q_1 = (1-\theta)[P(Q) + P'(Q)q_1 - c'(q_1)] = 0, \tag{2a}$$

$$\partial V_2/\partial q_2 = P(Q) + P'(Q)q_2 - c'(q_2) + \theta q_1 P'(Q) = 0. \tag{2b}$$

Note that equation (2a) implies that firm 1's best response is unaffected by the $(1-\theta)$ term. Thus, its best-response curve is the same as it would be if firm 2 were not potentially liable to firm 1 for damages. In equilibrium firm 1's output will differ because firm 2 is directly affected by θ in equation (2b), because the damages firm 2 pays depend on how much it produces while the trial is occurring. Under standard assumptions that the reaction functions are each downward sloping and that the equilibrium is best-response stable, it is easy to show that the determinant of the Jacobian of the system of first-order conditions, $|H|$, is positive in sign, and the cross partial derivatives $\partial^2 V_i/\partial q_i \partial q_j$ are each negative in sign. Therefore, $dq_1^*/d\theta = q_1 P'(Q)|H|^{-1}(\partial^2 V_2/\partial q_2 \partial q_1) > 0$ and $dq_2^*/\mathrm{d}\theta = -(\partial^2 V_1/\partial {q_1}^2) q_1 P'(Q)|H|^{-1} < 0$. Define $\pi_1(\theta) \equiv P(Q^*)q_1^* - c(q_1^*)$ and $\pi_2(\theta) \equiv P(Q^*)q_2^* - c(q_2^*)$ as the trial period profits evaluated at the Nash equilibrium output levels. Then by the envelope theorem, the following results may be obtained:

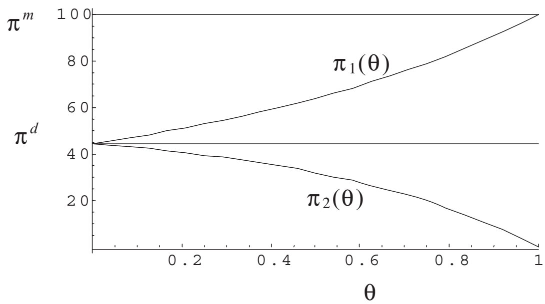
Lemma 1: *Under the damage rules, $D_2 = \pi^d$ and $D_1 = \pi^m - \pi_1(\theta)$, if the best-response functions are decreasing in the other firm's output and are stable, then the functions $\pi_1(\theta)$ and $\pi_2(\theta)$ obey*

$$\pi_1'(\theta) = q_1^* P'(Q^*)\frac{dq_2^*}{d\theta} > 0 \tag{3a}$$

$$\pi_2'(\theta) = -\theta q_1^* P'(Q^*)\frac{dq_2^*}{d\theta} + q_2^* P'(Q^*)\frac{dq_1^*}{d\theta} < 0. \tag{3b}$$

$$\theta\pi_1'(\theta) + \pi_2'(\theta) < 0. \tag{3c}$$

As the probability firm 1 is successful in upholding its patent rises, firm 2's profits fall and firm 1's profits rise. In the limit as $\theta \to 0$, $\pi_1(0) =$



NOTES:—Drawn with demand $P(Q) = a - Q$, and marginal cost c, with $a - c = 20$. Thus, $\pi^m = 100$ and $\pi^d = 44.4$.

FIGURE 2. FIRM PROFITS AS A FUNCTION OF THE PROBABILITY THE PATENT IS FOUND VALID

$\pi_2(0) = \pi^d$, because if there is zero chance that firm 1 wins at trial, firm 2 expects to pay no damages and thus each firm earns duopoly profits. Similarly, as $\theta \to 1$, $\pi_1(1) \to \pi^m$ and $\pi_2(1) \to 0$, because firm 2 realizes it will be penalized if it produces. The condition (3c) follows immediately from (3a) and (3b). Lemma 1 generalizes a result from Shapiro (2003). From this point on, we shall ignore the quantity choices by the firms, but these choices are implicit in the indirect profit functions $\pi_1(\theta)$ and $\pi_2(\theta)$. These functions are plotted in Figure 2 for the case of linear demand and constant marginal cost.

At node 5, firm 1 decides whether or not to seek a preliminary injunction, having already sued for infringement and discovered that firm 2 is willing to defend. It might seem that a patentee is more likely to seek a preliminary injunction the greater the probability of a finding of infringement. However, this is mistaken, as the first proposition shows:

PROPOSITION 1: *For $\phi > 0$, firm 1 seeks a preliminary injunction when firm 2 enters and defends itself against infringement only if $\theta \le \theta_{SPI}$, where $0 < \theta_{SPI} < 1$ is the unique value of θ that solves*

$$\Delta\pi_1(SPI) \equiv \pi_1^{SPI} - \pi_1^{NSPI} = \phi(1-\theta)\left[\pi^m - \pi^d - \pi_1(\theta)\right] = 0. \tag{4}$$

Proof: Equation (4) gives the expected net benefit to firm 1 of seeking a preliminary injunction. $\Delta\pi_1(SPI)$ is decreasing in θ, given Lemma 1. As $\theta \to 0$, the expression in square brackets is $\pi^m - 2\pi^d > 0$ and as $\theta \to 1$, the expression in square brackets is $-\pi^d < 0$. Thus, let $\theta_{SPI} \in (0,1)$ denote the unique value of θ such that $\pi^m - \pi^d - \pi_1(\theta_{SPI}) = 0$. Therefore, for $\phi > 0$, it is optimal for firm 1 to choose to seek a preliminary injunction only when $\theta \le \theta_{SPI}$. □

This simple but important result is an artifact of the rule for damages to be paid by the potential infringer. For high θ, the amount of damages imposed on firm 1, $D_1 = \pi^m - \pi_1$, is quite small; however, the amount of damages firm 1 imposes on firm 2 by seeking a preliminary injunction, $D_2 = \pi^d$, is unaffected by θ. Thus, firm 1 has little incentive to seek a preliminary injunction in that case. However, when θ is close to zero, D_1 is close to $\pi^m - \pi^d$, which is larger than duopoly profits, and the expected damages paid to firm 2 are $\theta\pi^d$, which is quite small. Thus, firm 1 wishes to seek a preliminary injunction exactly when its probability of success in the patent suit is small. In the linear demand and constant marginal cost duopoly case, $\theta_{SPI} \approx 1/3$, so that firm 1 seeks a preliminary injunction only if its probability of winning at trial is less than one-third. Given our focus is preliminary injunctions, we ignore the case where $\theta > \theta_{SPI}$ below.

Next, consider the choice by firm 2 at node 4 to defend or not to defend itself against patent infringement subsequent to entry, given that firm 1 seeks a preliminary injunction if firm 2 defends itself against infringement. Then the net profits to firm 2 of defending against infringement are given by

$$\begin{aligned}\Delta\pi_2(D \mid SPI) &\equiv \pi_2^D - \pi_2^{ND} \\ &= (1-\phi)\big\{\pi_2(\theta) + (1-\theta)\beta\pi^d - \theta\big[\pi^m - \pi_2(\theta)\big]\big\} \\ &\quad + \phi(1-\theta)(1+\beta)\pi^d - c_{L_2}.\end{aligned} \tag{5}$$

Setting $\Delta\pi_2(D \mid SPI)$ equal to zero and differentiating with respect to ϕ and θ yields

$$\begin{aligned}&\big\{\pi^d - \pi_2(\theta) + \theta\big[\pi^m - \pi_1(\theta) - \pi^d\big]\big\}\, d\phi \\ &\quad + \big\{(1-\phi)\big[\pi_2'(\theta) + \theta\pi_1'(\theta) - \pi^m + \pi_1(\theta)\big] - (\phi+\beta)\pi^d\big\}\, d\theta = 0.\end{aligned} \tag{6}$$

By Lemma 1 and Proposition 1, the $d\phi$ coefficient is positive and the $d\theta$ coefficient is negative. The locus where firm 2 is indifferent between defending and not defending is given by

$$\phi_D(\theta) = \frac{\theta\big[\pi^m - \pi_1(\theta)\big] - \pi_2(\theta) - (1-\theta)\beta\pi^d + c_{L_2}}{\pi^d - \pi_2(\theta) + \theta\big[\pi^m - \pi_1(\theta) - \pi^d\big]}, \quad \text{for } \theta \leq \theta_{SPI}. \tag{7}$$

Thus, by equation (6), the function $\phi_D(\theta)$ along which $\Delta\pi_2(D \mid SPI) = 0$ is increasing in θ. As $\theta \to 0$, $\phi_D(\theta) \to -\infty$. Thus, for sufficiently small θ, firm 2 will defend itself in the patent suit no matter what the probability of a preliminary injunction is. Firm 2's decision is summarized as follows:

Proposition 2: *For any $\theta \leq \theta_{SPI}$, firm 2 will defend itself against infringement only if $\phi > \phi_D(\theta)$.*

Next, we turn to the decision by firm 1 at node 3 of whether or not to sue for infringement given that firm 2 has chosen to defend itself against infringement. When $\theta \leq \theta_{SPI}$, if firm 1 chooses *SFI* it earns expected profits π_1^{SPI}, because it will also seek a preliminary injunction, and if it chooses *NSFI*, it earns expected profits π_1^{NSFI}. Thus, the net benefit to firm 1 of suing for infringement is given by

$$\begin{aligned}\Delta\pi_1(SFI \mid D) &\equiv \pi_1^{SPI} - \pi_1^{NSFI} \\ &= \phi(1-\theta)\big[\pi^m - \pi^d - \pi_1(\theta)\big] + \theta\big[\beta(\pi^m - \pi^d) + \pi^m \\ &\qquad - \pi_1(\theta)\big] + \pi_1(\theta) - \pi^d - c_{L_1}. \end{aligned} \tag{8}$$

The locus of points where Firm 1 is indifferent between suing for infringement and not suing for infringement is given by solving $\Delta\pi_1(SFI \mid D) \equiv 0$ for ϕ as a function of θ:

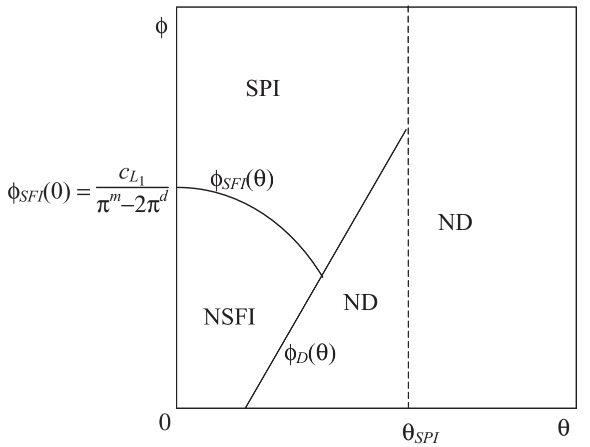
$$\phi_{SFI}(\theta) = \frac{c_{L_1} - \theta\big[\beta(\pi^m - \pi^d) + \pi^m - \pi_1(\theta)\big] - \pi_1(\theta) + \pi^d}{(1-\theta)\big[\pi^m - \pi^d - \pi_1(\theta)\big]}, \text{ for } \theta \leq \theta_{SPI}. \tag{9}$$

Because $\partial\Delta\pi_1(SFI \mid D)/\partial\phi > 0$ by Proposition 1, firm 1 chooses *SFI* over *NSFI* only if $\phi > \phi_{SFI}(\theta)$. The value of ϕ_{SFI} such that the firm is indifferent between suing for infringement and not suing for infringement when it has zero chance of succeeding (i.e., $\theta = 0$) is given by $\phi_{SFI}(0) = c_{L_1}/(\pi^m - 2\pi^d)$. This value is the vertical intercept of the locus of ϕ_{SFI} shown in Figure 3. Because $\Delta\pi_1(SFI \mid D)$ is increasing in ϕ, if $c_{L_1} < \pi^m - 2\pi^d$, then there exist values of ϕ such that even when $\theta = 0$, firm 1 will sue for infringement just to have a chance of earning monopoly profits during a preliminary injunction. The condition $c_{L_1} < \pi^m - 2\pi^d$ in effect requires that the private gains to firm 1 from monopolizing be greater than the total possible damages plus own litigation costs.

Evaluating $\phi_{SFI}(\theta)$ at θ_{SPI}, we see by Proposition 1 that the denominator vanishes. When litigation costs are sufficiently small (i.e., $c_{L_1} < \pi^m - 2\pi^d$), firm 1 sues for infringement even when $\theta = 0$ if ϕ is sufficiently high. In this case, the numerator of (9) may be written as

$$\begin{aligned} & c_{L_1} - \theta_{SPI}\big[\beta(\pi^m - \pi^d) + \pi^m - \pi_1(\theta_{SPI})\big] - \pi_1(\theta_{SPI}) + \pi^d < \pi^m - \pi^d \\ &\qquad - \pi_1(\theta_{SPI}) - \theta_{SPI}\big[\beta(\pi^m - \pi^d) + \pi^m - \pi_1(\theta_{SPI})\big] \\ &\quad = -\theta_{SPI}[\beta(\pi^m - \pi^d) + \pi^d] < 0 \end{aligned} \tag{10}$$

Thus, as $\theta \to \theta_{SPI}$, $\phi_{SFI}(\theta) \to -\infty$. This means there exist some values of $\theta < \theta_{SPI}$ such that firm 1 will sue for infringement even when the probability



Notes:—ϕ is the probability a preliminary injunction is granted. θ is the probability the patent is found valid. This drawn under the assumption that $c_{L_1} < \pi^m - 2\pi^d$ so that $\phi_{SFI}(0) < 1$.

FIGURE 3. SUBGAME PERFECT EQUILIBRIA TO THE LITIGATION GAME

of getting a preliminary injunction is zero. We summarize this analysis as follows:

Proposition 3: *Suppose that $\theta \le \theta_{SPI}$. Then if $c_{L_1} < \pi^m - 2\pi^d$, firm 1 will sue for infringement only if $\phi > \phi_{SFI}(\theta)$. If $c_{L_1} < \pi^m - 2\pi^d$, firm 1 will not sue for infringement for any ϕ when $\theta = 0$, and will sue for infringement only if $\phi > \phi_{SFI}(\theta)$ when $\theta > 0$.*

Firm 1's possible equilibrium outcomes with respect to litigation, when $\theta \le \theta_{SPI}$, are depicted in Figure 3. The area *ND* to the right of θ_{SPI} occurs because $\phi_D(\theta_{SPI}) > 0$ implies that firm 2 will choose *ND* when firm 1 chooses *NSPI*. The locus $\phi_D(\theta)$ is the boundary between where firm 2 chooses to defend itself if sued for infringement. The locus $\phi_{SFI}(\theta)$ defines the boundary dividing whether or not firm 1 will sue for infringement (region *SPI*) or not (region *NSFI*) by Proposition 3. For very low values of both ϕ and θ, firm 1 will not sue for infringement, because litigation costs are too high relative to the expected gain. For higher values of ϕ, however, it is profitable for firm 1 to sue for infringement even when the probability that it would be successful is low or even nil so long as $c_{L_1} < \pi^m - 2\pi^d$.

4. The Entry and Innovation Subgames

We now turn to an analysis of the entry decision by firm 2 and then the innovation decision by firm 1, recognizing that entry and innovation costs c_I and c_E are avoidable by not innovating and not entering, respectively. When $\theta \leq \theta_{SPI}$, the entrant faces two possible situations. If firm 1 will not sue for infringement, the gain to firm 2 from entering is $\Delta\pi_2(E \mid NSFI) = (1+\beta)\pi^d - c_E$. If this is not positive in sign, firm 2 will never enter. Thus we assume in what follows that $c_E < (1+\beta)\pi^d$. In the case where firm 1 both sues for infringement and seeks a preliminary injunction, the expected gain to firm 2 from entering is

$$\begin{aligned}\Delta\pi_2(E \mid SPI) = (1-\phi)\big\{\pi_2(\theta) + (1-\theta)\beta\pi^d - \theta\big[\pi^m - \pi_1(\theta)\big]\big\} \\ + \phi(1-\theta)(1+\beta)\pi^d - c_E - c_{L_2}. \end{aligned} \tag{11}$$

Setting $\Delta\pi_2(E \mid SPI) = 0$ and differentiating with respect to ϕ and θ yields

$$\begin{aligned} &d\,\Delta\pi_2(E \mid SPI) \\ &\quad = \big\{(1-\phi)\big[\theta\pi_1'(\theta) + \pi_2'(\theta)\big] - (1-\phi)\big[\pi^m - \pi^d - \pi_1(\theta)\big] \\ &\qquad - \phi(1+\beta)\pi^d\big\}d\theta + \big\{\pi^d - \pi_2(\theta) + \theta\big[\pi^m - \pi^d - \pi_1(\theta)\big]\big\}\,d\phi = 0. \end{aligned} \tag{12}$$

When $\theta \leq \theta_{SPI}$, the coefficient on $d\theta$ is negative by Lemma 1 and the coefficient on $d\phi$ is positive. Setting $\Delta\pi_2(E \mid SPI) = 0$ and solving for the locus $\phi_E(\theta)$ where firm 2 is indifferent to entering yields

$$\phi_E(\theta) = \frac{c_E + c_{L_2} + \theta\big[\pi^m - \pi_1(\theta)\big] - \pi_2(\theta) - (1-\theta)\beta\pi^d}{\pi^d - \pi_2(\theta) + \theta\big[\pi^m - \pi^d - \pi_1(\theta)\big]}, \quad \text{for } \theta \leq \theta_{SPI}. \tag{13}$$

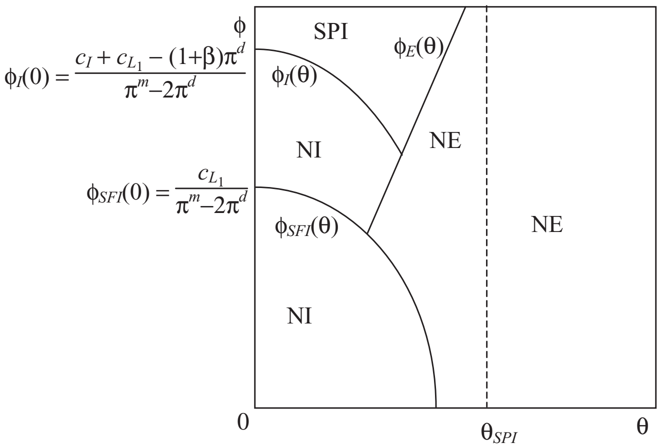
From equation (12), the function $\phi_E(\theta)$ where firm 2 is indifferent between entering or staying out of the market is an upward-sloping function. Furthermore, comparing equation (13) with equation (7) reveals that the $\phi_E(\theta)$ locus lies above the $\phi_D(\theta)$ locus:

$$\phi_E(\theta) - \phi_D(\theta) = \frac{c_E}{\pi^d - \pi_2(\theta) + \theta\big[\pi^m - \pi_1(\theta) - \pi^d\big]} > 0, \quad \text{for } \theta \leq \theta_{SPI}. \tag{14}$$

This implies that whenever firm 2 would not subsequently defend a patent infringement case, it will also not enter. Thus, *ND* is eliminated as a subgame perfect equilibrium outcome. The $\phi_E(\theta)$ locus is shown in Figure 4. Proposition 4 summarizes firm 2's entry decision.

Proposition 4: *Suppose that $\theta \leq \theta_{SPI}$. When firm 1 is willing to sue for infringement, firm 2 enters only if $\phi > \phi_E(\theta)$.*

Proposition 4 shows that firm 2 benefits from a high probability of the court granting a preliminary injunction. The derivative of $\Delta\pi_2(E \mid SPI)$ in equation (12) with respect to ϕ is always positive for $\theta \leq \theta_{SPI}$ by Lemma 1 and Proposition 1. The benefit to firm 2 of a high ϕ is that by being enjoined from producing, firm 2 lowers its expected



Notes:—ϕ is the probability a preliminary injunction is granted. θ is the probability the patent is found valid. This Fig. is drawn under the assumption that $c_{L_1} < \pi^m - 2\pi^d$.

FIGURE 4. SUBGAME PERFECT EQUILIBRIA WITH ENTRY AND INNOVATION WHEN $C_I > (1+\beta)\pi^d$

liability of damages it might have to pay to firm 1. By entering when firm 1 will seek a preliminary injunction, firm 2 buys a lottery at price $c_E + c_{L_2}$ in which it has probability $\phi(1-\theta)$ of earning profits $(1+\beta)\pi^d$, but is liable for damages $D_1 = \pi^m - \pi_1(\theta)$ with probability $(1-\phi)\theta$. Thus as ϕ increases, firm 2's expected profits rise.

Next, we turn to the analysis of when firm 1 will innovate. When $\theta \leq \theta_{SPI}$, there are three cases to consider, corresponding to the possible outcomes *NE*, *NSFI*, and *SPI*. When firm 2 does not enter (outcome *NE*), firm 1's profits if it innovates are $(1+\beta)\pi^m - c_I$. We assume that this is positive, otherwise firm 1 never innovates. When firm 2 enters and firm 1 subsequently does not sue for infringement (outcome *NSFI*), firm 1's profits are $(1+\beta)\pi^d - c_I$. If this is negative, firm 1 will innovate only if it can credibly keep firm 2 from entering. If it is positive, firm 1 will innovate for any ϕ and θ, including $\phi = \theta = 0$.

The most interesting case occurs when firm 2 defends itself against patent infringement and firm 1 subsequently seeks a preliminary injunction (outcome *SPI*). Then firm 1's expected gain in profits if it innovates is

$$\Delta\pi_1(I \mid D, SPI) = \phi[\pi^m + \theta\beta\pi^m + (1-\theta)(1-\beta)\pi^d] + (1-\phi)\big\{\pi_1(\theta) + \theta\big[(1+\beta)\pi^m - \pi_1(\theta)\big] + (1-\theta)\beta\pi^d\big\} - c_I - c_{L_1}. \quad (15)$$

Setting $\Delta\pi_1(I \mid D, SPI) = 0$ and solving for the locus $\phi_I(\theta)$ where firm 1 is indifferent between innovating and not innovating when it will seek a preliminary injunction if it innovates yields:

$$\phi_I(\theta) = \frac{c_I + c_{L_1} - (1-\theta)\beta\pi^d - \theta(1+\beta)\pi^m - (1-\theta)\pi_1(\theta)}{(1-\theta)\left[\pi^m - \pi^d - \pi_1(\theta)\right]}, \quad \text{for } \theta \le \theta_{SPI}. \tag{16}$$

The denominator of equation (16) corresponds to the rate $\partial\Delta\pi_1(I \mid SPI)/\partial\phi$, which is positive when $\theta \le \theta_{SPI}$ by Proposition 1. Thus, firm 1's innovation rule is given by the following:

Proposition 5. *When $\theta \le \theta_{SPI}$ and firm 1 will seek a preliminary injunction if firm 2 defends itself, firm 1 will innovate only if $\phi > \phi_I(\theta)$.*

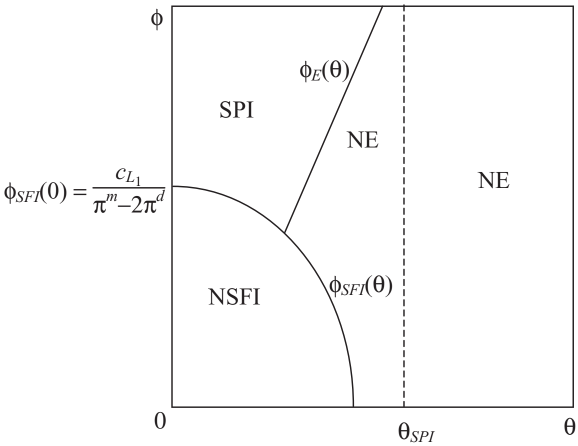
Next, notice that the difference between $\phi_I(\theta)$ and $\phi_{SFI}(\theta)$ depends on the sign of $c_I - (1+\beta)\pi^d$:

$$\phi_I(\theta) - \phi_{SFI}(\theta) = \frac{c_I - (1+\beta)\pi^d}{(1-\theta)\left[\pi^m - \pi^d - \pi_1(\theta)\right]}, \quad \text{for } \theta \le \theta_{SPI}. \tag{17}$$

Because equation (17) implies that $\phi_I(\theta) > \phi_{SFI}(\theta)$ everywhere when $c_I > (1+\beta)\pi^d$, we can infer that in this case there exists a region of $\{\phi, \theta\}$ space where firm 1 would have sued for infringement if it had innovated and firm 2 had entered, but that firm 1 will not innovate in this region. This is the case shown in Figure 4. However, if $c_I < (1+\beta)\pi^{\mathrm{d}}$, then firm 1 will always wish to innovate, because it is profitable to innovate even given certain duopoly competition. Thus, if $\phi_{\mathrm{I}}(\theta) < \phi_{SFI}(\theta)$, firm 1 will innovate for any value in the region below $\phi_{SFI}(\theta)$. This is the case shown in Figure 5.

Propositions 4 and 5 show that under existing damage rules, both the innovator and the imitator prefer ϕ to be high in the case where a preliminary injunction is sought,[14] even though they obviously differ in their preferences over θ. Because both the innovator and imitator benefit from higher ϕ, preliminary injunction hearings may lack the adversarial characteristic one might expect. Although we have modeled ϕ as an exogenous parameter based on the underlying merits of each case, in practice ϕ must be in part determined by the litigation efforts of the firms. However, if neither firm has an incentive to stop the issuance of a preliminary injunction, the court ruling on the case may not be fully informed, leading to a higher ϕ than would be supported by the underlying merits. Thus, it is not implausible that an innovation

14. Lanjouw and Lerner (1996, 2001) make a similar point.



Notes:—ϕ is the probability a preliminary injunction is granted. θ is the probability the patent is found valid. This Fig. is drawn under the assumption that $c_{L_1} < \pi^m - 2\pi^d$.

FIGURE 5. SUBGAME PERFECT EQUILIBRIUM WITH ENTRY AND INNOVATION WHEN $C_I < (1+\beta)\pi^d$

could have both a low θ and a high ϕ—which leads to area SPI in the panels of Figures 3-5.[15]

5. The Effect of Preliminary Injunctions on Social Welfare

In this section, we show that the welfare effects of an increase in ϕ in the region where a preliminary injunction is sought are the opposite of the preferences of the firms and we propose a simple Pigouvian remedy. Expected social welfare is defined as the sum of industry profits plus consumer surplus less innovation, entry, and litigation costs. Let $S^m \leq S^{12}(\theta) \leq S^d$ denote the consumer surplus, respectively, under monopoly, asymmetric duopoly with profits $\pi_1(\theta)$ and $\pi_2(\theta)$, and symmetric duopoly. Thus, gross welfare is increasing in the degree of competition:

$$W^m = \pi^m + S^m \leq W^{12}(\theta) = \pi_1(\theta) + \pi_2(\theta) + S^{12}(\theta) \leq 2\pi^d + S^d = W^d. \tag{18}$$

We may write down the expected welfare in the subgame perfect equilibrium outcome areas:

15. Another example of high ϕ independent of θ occurs in pharmaceutical markets, where ϕ is effectively set equal to one because patentees are granted an *automatic* 30-month stay under the Hatch-Waxman Act.

$$
\begin{aligned}
EW^{NI}(\phi,\theta) &\equiv 0,\\
EW^{NE}(\phi,\theta) &\equiv (1+\beta)W^m - c_I,\\
EW^{NSFI}(\phi,\theta) &\equiv W^d(1+\beta) - c_I - c_E,\\
EW^{NSPI}(\phi,\theta) &\equiv W^{12}(\theta) + \theta\beta W^m + (1-\theta)\beta W^d - c_I - c_E - c_{L_1} - c_{L_2},\\
EW^{SPI}(\phi,\theta) &\equiv \phi W^m + (1-\phi)W^{12}(\theta) + \theta\beta W^m + (1-\theta)\beta W^d - c_I\\
&\quad - c_E - c_{L_1} - c_{L_2}. \qquad (19)
\end{aligned}
$$

Each expression in equation (19) is nonnegative, because firm 1 innovates and firm 2 enters ignoring consumer's surplus. The welfare result is stated in the next proposition:

Proposition 6: *Suppose that $\theta < \theta_{SPI}$. Setting ϕ as low as possible, contingent upon obtaining innovation and imitation, maximizes expected aggregate welfare.*

Proof: In region *SPI*, expected welfare is decreasing in ϕ because $\partial EW^{SPI}/\partial\phi = W^m - W^{12}(\theta) < 0$. In region *NSFI*, welfare is unaffected by ϕ. At the boundary between *SPI* and *NSFI*, a decrease in ϕ increases welfare discontinuously. □

From Propositions 4 and 5, both the innovator and the imitator wish for ϕ to be as large as possible in region *SPI*, while Proposition 6 shows that social welfare is improved by having ϕ as small as possible. Therefore, the damage rules we analyzed above are suboptimal. The problem is that under current damage rules, firm 1 benefits the most from a high chance of being granted a preliminary injunction when the probability that it wins at trial is the smallest.[16] Because firm 2 also benefits from a high probability of a preliminary injunction being granted, preliminary injunctions are most likely to be sought for patents with a low probability of being upheld at trial.

Consider the following change to the damage rules. Suppose that when firm 1 successfully obtains a preliminary injunction on a patent that is later declared invalid, it pays damages $D_2 = \pi^d$ to firm 2 and a fine, $D_C = S^d - S^m$, to account for consumer losses. As before, the damages to firm 1 in case firm 2 is ultimately found infringing are $D_1 = \pi^m - \pi_1(\theta)$. This is still a second-best solution, as it does not solve the problem where firm 1 cannot innovate or firm 2 cannot enter because they cannot capture consumer's surplus, but the next proposition shows that it fixes the problem of preliminary injunctions being sought when the chance of success at trial is low.

16. From (4), the rate at which the $\Delta\pi_1(SPI)$ is increasing in ϕ is largest at $\theta = 0$.

Proposition 7: *If firm 1 is liable for damages both to firm 2 and to consumers, firm 1 will not seek a preliminary injunction when firm 2 has chosen to defend itself against allegations of patent infringement.*

Proof: Under these damage rules, firm 1's expected profits if it seeks a preliminary injunction are

$$\begin{aligned}\pi_1^{SPI} &= \phi\big[\pi^m + \theta\beta\pi^m + (1-\theta)(\beta\pi^d - D_2 - D_C)\big] \\ &\quad + (1-\phi)\big[\pi_1(\theta) + \theta(\beta\pi^m + D_1) + (1-\theta)\beta\pi^d\big] - c_I - c_{L_1}.\end{aligned} \tag{20}$$

Firm 1's expected profits if it chooses not to seek a preliminary injunction are given by π_1^{NSPI}, which is unchanged. Therefore, the net gain to firm 1 of seeking a preliminary injunction if firm 2 defends itself for patent infringement is

$$\Delta\pi_1(SPI) = \pi_1^{SPI} - \pi_1^{NSPI} = \phi(1-\theta)\{W^m - W^d - [\pi_1(\theta) - \pi^d]\}. \tag{21}$$

The expression in curly brackets is negative for all $\theta < 1$, because $W^m < W^d$ and $\pi_1(\theta) \geq \pi^d$. □

Given that firm 1 does not have an incentive to seek a preliminary injunction, the remainder of the game unfolds as follows. If firm 1 has innovated and firm 2 has entered and defends itself against patent infringement, firm 1 sues for infringement only if the following is positive:

$$\begin{aligned}\Delta\pi_1(SFI) = \pi_1^{NSPI} - \pi_1^{NE} &= \pi_1(\theta) - \pi^d + \theta\beta(\pi^m - \pi^d) \\ &\quad + \theta[\pi^m - \pi_1(\theta)] - c_{L_1}.\end{aligned} \tag{22}$$

As $\theta \to 0$, the expression in equation (22) becomes $\Delta\pi_1(SFI) = -c_{L_1} < 0$, and as $\theta \to 1$, $\Delta\pi_1(SFI) = (1+\beta)(\pi^m - \pi^d) - c_{L_1}$. Lemma 1 implies that $\Delta\pi_1(SFI)$ is increasing in θ. Thus if $(1+\beta)(\pi^m - \pi^d) > c_{L_1}$, there exists a value θ_{SFI} such that $\Delta\pi_1(SFI) = 0$, and firm 1 sues for patent infringement only if $\theta > \theta_{SFI}$.

As before, firm 2 will never enter and then not defend itself if sued for infringement. When $\theta < \theta_{SFI}$, firm 2 enters, because $(1+\beta)\pi^d > c_E$. When $\theta > \theta_{SFI}$, firm 1 sues for infringement, and firm 2 enters only if its expected net profits from entering are positive:

$$\Delta\pi_2(E \mid SFI) = \pi_2^{NSPI} = \pi_2(\theta) + (1-\theta)\beta\pi^d - \theta[\pi^m - \pi_1(\theta)] - c_E - c_{L_2}. \tag{23}$$

By Lemma 1, firm 2's expected gain from entering $\Delta\pi_2(E \mid SFI)$ is decreasing in θ. As $\theta \to 1$, $\Delta\pi_2(E \mid SFI) = -c_E - c_{L_2} < 0$, and as $\theta \to 0$, $\Delta\pi_2(E \mid SFI) = (1+\beta)\pi^d - c_E - c_{L_2}$. If the stream of duopoly profits is less than entry and litigation costs, then firm 2 never enters. If it is positive, then there exists some value of θ_E such that firm 2 will enter when it is being sued for infringement if $\theta < \theta_E$, where θ_E solves $\Delta\pi_2(E \mid SFI) = 0$. Thus firm 2 enters when the patent is unlikely to be upheld at trial.

Whether firm 1 innovates or not depends upon which of three possible subgames in which it finds itself. If firm 2 does not enter (*NE*), firm 1 innovates because $(1+\beta)\pi^m > c_I$. If firm 2 enters and firm 1 will not subsequently sue (*NSFI*), firm 1 innovates only if $(1+\beta)\pi^d > c_I$. Finally, if firm 2 enters and firm 1 subsequently sues for patent infringement (*NSPI*), firm 1's net expected profits from innovating are

$$\Delta\pi_1(I \mid NSPI) = \pi_1(\theta) + \theta[(1+\beta)\pi^m - \pi_1(\theta)] + (1-\theta)\beta\pi^d - c_I - c_{L_1}. \tag{24}$$

As $\theta \to 0$, $\Delta\pi_1(I \mid NSPI) = (1+\beta)\pi^d - c_I - c_{L_1}$, and as $\theta \to 1$, $\Delta\pi_1(I \mid NSPI) = (1+\beta)\pi^m - c_I - c_{L_1}$. Let θ_I denote the value of $\theta \in [0,1]$, such that $\Delta\pi_1(I \mid NSPI) = 0$. Such a value will exist so long as $(1+\beta)\pi^m > c_I + c_{L_1} > (1+\beta)\pi^d$. Because $\partial\Delta\pi_1(I \mid NSPI)/\partial\theta = (1-\theta)\pi_1'(\theta) + \pi^m - \pi_1(\theta) + \beta(\pi^m - \pi^d) > 0$, θ_I is unique and firm 1 innovates if and only if $\theta > \theta_I$. Comparing equation (22) and equation (24), it can be shown that $\theta_I > \theta_{SFI}$ if, and only if, $(1+\beta)\pi^d > c_I$. Thus when $(1+\beta)\pi^d < c_I$ there exists values of θ such that firm 1 will innovate and not sue for infringement if firm 2 enters, and when $(1+\beta)\pi^d > c_I$ firm 1 sue for infringement whenever it innovates and firm 2 enters.

When preliminary injunctions are not involved, firm 1 innovates only if the probability of winning at trial is sufficiently large. Thus the equilibrium innovation and entry decisions satisfy:

Proposition 8: *Given that firm 1 will not seek a preliminary injunction under the damage rules with D_C, firm 1 innovates only if $\theta > \theta_I$; firm 2 enters only if $\theta < \theta_E$; and firm 1 sues for infringement only if $\theta > \theta_{SFI}$.*

These results differ from the case where damages are not paid to consumers in that innovation and entry depend *only* on the probability of success at trial on the merits of the case, and are independent of the likelihood of a preliminary injunction. Given that θ is the probability that the court finds the patent sufficiently novel to be upheld as novel at trial, under these damage rules, firm 1 innovates when the innovation's patent is more likely to be found novel, and firm 2 enters when the innovation is likely to be determined to be not sufficiently novel.

The damage rule we propose does not achieve the first-best, in that innovators still do not consider consumer surplus when making the decision to invest in innovation. It might be thought that preliminary injunctions under current damage rules provide an impetus for innovation by granting monopolies in cases where even monopoly power is not sufficient to induce the innovation. However, this is not the case.

Although preliminary injunctions raise expected profits, they still yield expected profits less than monopoly profits. More importantly, they are sought only when the innovation is unlikely to be found sufficiently novel by the courts.

6. Conclusions

This paper shows that an asymmetry between the rewards and damages creates an incentive for patentees to pursue preliminary injunctions and for imitators to acquiesce. Under US patent law, the patentee gains more from obtaining a preliminary injunction than he must pay in damages if the imitator is found not to have infringed; and the damages paid to a wrongly enjoined imitator are larger than the profits the imitator would have earned had no injunction been granted. This leads to several undesirable results. First, patentees gain the most from preliminary injunctions when the probability of successfully upholding the patent at trial is low. An implication is that preliminary injunctions may be sought to obtain market power for the period of the injunction on patents of questionable merit. Second, the expected profits of both the patentee and the imitator increase with the probability of a preliminary injunction. This implies that when preliminary injunctions are sought for questionable patents, they may not be opposed by the infringing party. Thus, a preliminary injunction may serve as a court-directed collusive arrangement.

This paper has also shown that social welfare can be improved by a damage rule in which a patentee who wins a preliminary injunction in a patent infringement suit that it ultimately loses is required to pay damages not only to the wrongly enjoined firm, but also a fine equal to lost consumer's surplus. This approach would not penalize innovators with truly novel patents, but would strip away the excess profits created by preliminary injunctions granted on the basis of invalid patents. This simple solution eliminates the problems created by preliminary injunctions under current damage rules.

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