Patent Litigation as an Information Transmission Mechanism

by

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Abstract

The literature on patent protection assumes a so-called "fencepost" system, in which there would be no need to refer to the courts over questions of interpretation. In reality, we observe a myriad of patent infringement suits through which questions of utility, novelty, and nonobviousness are independently ruled on by a court. Therefore, patent litigation accompanying initial imitations can reveal important information about the validity of the contested patents to other potential entrants. This paper explores the implications of such information revelation through patent litigation. It is shown that the payoffs for the patentee and the initial imitator are highly discontinuous in the degree of patent protection. Furthermore, strengthening intellectual property rights is not necessarily desirable for the patentee. The analysis also has implications for interpreting empirical data on imitation lags.

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I. Introduction

This paper explores the implications of patent infringement litigation for the overall patent system. More specifically, I focus on the role of patent suits in conveying information regarding the validity and enforceability of the patents in dispute. I show that the incorporation of such informative patent litigation into the process of patent enforcement generates a rich set of predictions for the imitation-based entry dynamics when there are multiple potential entrants. Furthermore, these results also have implications for the interpretation of empirical data on imitation and the incentive to innovate.

On the recognition that knowledge is inherently a public good, the patent system purports to confer perfect appropriability by granting legal monopoly of an invention (for a limited time) to restore the incentive to engage in innovative activity. This idealization underlies most of the theoretical work concerning the economics of innovation and patents [Arrow (1962), Dasgupta and Stiglitz (1980), and Nordhaus (1969), etc.].

The empirical studies, however, reveal that patent protection is not perfect and imitation is a common occurrence [Mansfield et al. (1981) and Levin et al. (1987)]. Subsequently, the possibility of imitation or "inventing around" patents has been formally incorporated into theoretical models [Benoit (1985), Katz and Shapiro (1987), Dasgupta (1988), and Gallini (1992)]. All these papers, despite making advances over the previous literature in that they account for the empirical fact, still retain the assumption that the interpretation of the patent scope is exact and there is no need to refer to the courts over questions of interpretation; in the jargon of the legal literature on patent, the literature on patent protection assumes a so-called strict "fencepost" system.¹ This assumption is typified in the recent literature on the tradeoff between the patent scope and patent length [Gilbert and Shapiro (1990) and Klemperer (1990)]. In Klemperer's (1990) analysis, for instance, a patent's breadth measures how different competitors' products should be in

¹Notable exceptions are Meurer (1989) and Waterson (1990), which will be discussed below.
order not to infringe on the patent. To this end, a notion of distance is introduced in his formulation of patent scope: a patent of width $\omega$ prevents competing firms from producing product varieties within a distance $\omega$ from the patentholder's product in a horizontal product space. An implicit assumption in his analysis is that this distance is well-defined and known to all relevant participants. Consequently, there is no ambiguity regarding the occurrence of infringement.

In reality, however, the scope of patent is determined by both statutory authority and judicial interpretation; issuance of the patent does no more than confer a patent right that is "presumed" valid (35 U.S.C.A. Sec. 282). Uncertainty as to the validity and coverage of many patents makes dispute inevitable. Consequently, we observe a myriad of patent infringement suits through which questions of utility, novelty, and nonobviousness are independently ruled on by a court. To illustrate the importance of court decisions on patent validity in infringement suits, I point out that of the 294 patents contested in all federal appellate court between 1966 and 1971, only 89 (about 30%) were found valid (Kintner and Lahr, 1975). Therefore, patent litigation accompanying initial imitations can reveal important information about the validity of the contested patents for other potential entrants. This paper explores the implications of such information revelation through patent litigation. It is shown that the payoffs for the patentee and the initial imitator are highly discontinuous in the degree of patent protection. Furthermore, strengthening intellectual property rights is not necessarily desirable for the patentee.

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2Issuance does not guarantee validity. In this respect, a patent is nothing but the title to sue.
3Some legal commentators characterize a patent as an invitation to a law suit or a lottery ticket (Kitti, 1979). One important factor contributing to the uncertainty about patent validity is that most judges called upon to decide cases involving patents are wholly untrained in the physical sciences and technical matters. According to Rosenberg (1992), "[p]atent cases are the only cases argued by professionals and decided by amateurs (p. 2-8)." This problem, however, has been mitigated with the creation of a specialized federal appellate court to hear patent cases in 1982.
4See Scotchmer and Green (1990) and Scotchmer (1991) for an economic analysis of novelty requirement in a model of sequential innovations.
5Alternatively, I may assume that uncertainty lies in the amount of royalty payments the court decides that the patentee is entitled to.
The paper considers an imitation decision by potential entrants and the incumbent (patentee)’s response to entry via a patent infringement suit. The novelty of the paper comes from considering multiple potential entrants with endogenous entry timing. The basic premise of the paper is the observation that the outcome of a patent suit, i.e., how the court will interpret the law, is inherently uncertain for both the patentee and the accused infringer. For instance, the "doctrine of equivalents" entitles the patented invention to cover a certain range of equivalents. However, the exact boundary of the set of equivalents is impossible to draw. The matter of infringement can be reasonably assumed to be decided case by case. This has an important implication especially when there are multiple potential entrants. The reason is that an initial imitation attempt and its corresponding suit can reveal important information regarding the validity of the patent through the litigation process.

This information revelation can have an impact on the behavior of both the patentee and the potential imitators. First of all, if the imitated patent is held invalid and the patent is revoked, it clears the deck so as to make further entry immune from the threat of suit. In a patent dispute between Intel and AMD (Advanced Micro Devices), for instance, a court decision in favor of AMD could also be beneficial for other manufacturers of Intel-clone microprocessors such as Cyrix and NexGen. In a related intellectual property right case, Apple Computer Corp. has sued Microsoft and Hewlett-Packard (HP) for copyright infringement, claiming that Microsoft’s Windows program and HP’s New Wave software have copied the “look and feel” of Macintosh’s graphic-based operating system. When a ruling was made in favor of Microsoft and HP, it was hailed as a positive signal for other software developers “because it would free developers from the threat of litigation (New York Times, April 16, 1992).” Even though an early entrant can benefit from additional profits until other firms enter, one would expect that this potential

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6Steve Tobak, Cyrix’s vice president of corporate marketing, says “we want AMD to succeed” for an alternative computer chip architecture to survive [Snyder, 1995].
gain can be easily outweighed by the potential saving of a sunk entry cost, it may be better to be a second imitator since it can save fixed sunk costs of entry in the case of patent infringement. This creates an incentive to free ride on the information provided by an early imitator. The consequence is the possibility of the imitation process turning into a waiting game.\footnote{In the innovation literature, it has been recognized that the possibility of imitation can convert the innovation game from a race to a waiting game [Dasgupta (1988) and Katz and Shapiro (1987)]. However, to the best of my knowledge, this paper is the first one to point out the possibility of a waiting game in the imitation game \textit{ex post} innovation.}

For the patentee, it implies that launching an infringement suit may be a risky proposition. If her patent is revoked in the suit, it will facilitate further entry to the industry. This implies that the incentive to bring a suit increases with the number of entrants already in the market since the adverse effect of further entry gets smaller. As a result, I find a set of parameters, which I call the \textit{limit entry set}, where an initial entry occurs without any patent suit while a further entry is deterred. In this set, the patentee refrains from bringing the initial suit since the possible negative information effect outweighs the positive entry deterrence effect. In contrast, the second entrant is deterred with the threat of a patent suit, a threat that is credible due to the decreased concern about information revelation. In this case, the imitation game is a preemption game in which each potential entrant strives to be the first one to imitate, knowing that he will be accommodated without inviting further entry. The existence of the limit entry set can have dramatic effects on the overall behavior of the profit functions of the patentee and potential imitators. In particular, I show that the payoffs for the patentee and the initial imitator are highly discontinuous in the degree of patent protection. Furthermore, the strengthening of intellectual property rights is not necessarily desirable for the patentee.

This paper is closely related to the imitation literature. Katz and Shapiro (1987) and Dasgupta (1988) formally consider the possibility of imitation in patent races.\footnote{A recent paper by Jovanovic and MacDonald (1994) considers the process of technology diffusion in a competitive industry when a fixed number of firms reduces costs via two channels: innovating themselves or imitating their rivals' technologies.} Gallini...
(1992) improves on the previous papers by assuming costly imitation. Thereby, she endogenizes the decision to imitate through its dependence on the length and scope of patent protection. Contrary to the results of Gilbert and Shapiro (1990) and Klemperer (1990), she finds that in the presence of imitation costs the optimal patent policy involves a broad scope of patent and a short patent life. Interestingly, as in my paper, she finds that an increase in patent life may have no effect on or, paradoxically, may reduce the incentive to innovate. However, the mechanism through which this result obtains is completely different from the one in this paper; in her analysis, increasing patent life increases the number of competing products via a zero profit entry condition, while my analysis resorts to changes in the entry timing. Benoit (1985) is closest to this paper in that the effect of imitation on the innovator is generated through endogenized entry timing of the imitator. In his paper, there is uncertainty surrounding the profitability of innovation, which is revealed only over time. This creates an option value of waiting for the imitator; even though the waiting strategy entails a loss of temporary profits in the event that the innovation is favorable, it can save on a would-be failed investment. In contrast, the endogenized timing of entry in our paper arises from strategic interaction between multiple imitators either trying to free ride on information or preempt each other.

As pointed out earlier, all the papers mentioned above assume that either imitation is immune from infringement or innovation is nonpatentable. Therefore, their framework is not adequate to analyze the issues I am interested in, i.e., the information revelation role of the patent suit. Meurer (1989) and Waterson (1990) are notable exceptions in that their models incorporate a fully structured legal process in which a "signpost" system of patents is assumed. As in this paper, they consider uncertainty about the extent of protection a patent provides. The foci of their analyses, however, are quite different. Meurer's concern

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9Benoit's model also predicts nonmonotonicity of the innovator's profit in relevant parameters (cost of innovation and probability of success) if imitation is possible.

10In the "fencepost" interpretation of patent specifications, the perimeter of the patentee's claims is assumed to be clearly marked out. The "signpost" interpretation regards the patent specification as merely pointing the reader in the direction which he may not travel without a license.
is on patent licensing that is induced as part of a settlement agreement to avoid litigation regarding patent validity. Waterson's main contribution lies in exploring issues regarding the effects of patents on product variety selection. Since both of these models contain only a single entrant, the issue of information revelation does not arise.\footnote{Aoki and Hu (1995) analyze how the legal system influences a patentee’s licensing and litigation decisions and its effect on innovation incentives. Lanjouw (1994) estimates the value of patent protection in a model incorporating the relationship between litigation and aspects of the legal environment. Once again, both papers consider only one potential infringer and do not deal with the issue of information revelation.}

In focusing on the information revelation aspect of patent litigation, this paper is somewhat related to Horstman \textit{et al.} (1985). They assume that an innovating firm has private information regarding the profitability of imitation. As a result, in their model, the decision to patent can reveal some of the innovator's information to the competitor. In contrast, our analysis assumes a symmetric information structure between the patentee and the imitators since they are assumed to entertain the same assessment regarding the probability of infringement. The effect of information revelation arises only through further entry by a third party.

Finally, in terms of the overall dynamics of entry, the paper is similar to Bernheim (1984). He argues that when there is a sequence of potential entrants, the qualitative nature of the entry deterrence decision undertaken by incumbent firms is quite different from when there is but a single entrant. In particular, the sequential aspects of entry deterrence makes it possible that government policies designed to promote entry have the opposite effect of increasing industrial concentration. The reason is that the profitability of early entry is in turn determined in part by the ease with which future entrants can be deterred. However, as will be explained later, the underlying mechanisms through which the entry dynamics are generated are quite different across models.

The remainder of the paper is organized in the following way. In section II, I provide a basic two-period model in which the order of entry is exogenously fixed. The informational externalities provided by the first entrant is discussed. In section III, I
extend the basic model by allowing the timing of entry to be endogenously determined in an infinite horizon framework. It is shown that the nature of the entry game can be either one of waiting or preemption depending on the degree of patent protection. One important consequence is that contrary to intuition, the strengthening of patent protection can be harmful to the patentee as the entry game is changed from a waiting game to a preemption game. Section IV concludes with a discussion of possible extensions and limitations of the model.

II. The Basic Model: Exogenous Timing of Entry

I consider a simple model of sequential entry. There is an incumbent who has a patent for a new product or process. She faces a sequence of potential entrants. In each period there is one potential entrant who can enter the market by imitating the patented product. Once there is entry by an imitator, the incumbent (patentee) can take the entrant to court for patent infringement. The entry involves a sunk cost of $F$. This sunk cost can be interpreted as a cost of imitation as in Gallini (1992) or a fixed setup cost of tooling-up necessary for a new product.

Contrary to most of the previous literature, the central feature of the present paper is that the extent to which protection is provided by the patent is not precise, and even the validity of the patent itself can be challenged in the courts. One important consequence of incorporating this feature in the patent enforcement mechanism is that if there are multiple potential entrants, then the process of imitation and its accompanying patent litigation has a characteristic of public good; an early entrant can provide a valuable piece of information since the outcome of a patent suit reveals the profitability of entry for those who wait in
the wings. This information is valuable since entry involves a sunk cost, which can be saved if the court deems an imitated product to infringe the patent.

I consider a two-period model with two potential entrants, one in each period. This is the simplest framework which allows a meaningful analysis of informational externalities among potential entrants. \(^{12}\) Entry is allowed only at the beginning of each period. If there is entry, the incumbent chooses whether or not to litigate the entrant(s). In order to abstract from the strategic choice of entry timing, I assume that the order of entry is predetermined. The next section relaxes this assumption in an infinite horizon framework.

At the beginning of the first period, the first entrant decides whether or not to enter the market with an imitation of the patented product. If he decides not to enter the incumbent will be a monopolist for the first period. If he decides to enter, he has to sink a fixed cost of \(F\). Let the profits for the monopoly, duopoly, and triopoly per period be denoted by \(\Pi^M\), \(\Pi^D\), and \(\Pi^T\), respectively, where \(\Pi^M > \Pi^D > \Pi^T\). With this notation, I implicitly assume that those profits are symmetric between the incumbent and entrants. Since the imitated product can be inferior or superior to the original patented product, duopoly and triopoly profits need not to be the same across the patentee and imitators. This assumption is made only for the sake of saving notation and has no consequences for the main results. To avoid triviality of the analysis, I maintain the following assumption throughout the paper. \(^{13}\)

\[
\Pi^T - F > 0
\]  

\(^{12}\)In a survey study of Levin et al. (1987), most respondents believed only a few firms (three to five for a major innovation, six to ten for a typical innovation) were capable of duplicating new processes and products.

\(^{13}\)The corresponding assumption in the infinite horizon model of section III is \(\Pi^T/(1-\delta) - F > 0\).
The assumption assures that if there is no danger of infringement, it is profitable to enter the industry as a triopolist. If inequality (1) is violated, the market can accommodate at most two firms and the issue of information transmission does not arise.

In the face of entry, the incumbent can accommodate the entrant by sharing the market or take the entrant to court for a patent infringement. The uncertainty of the outcome of a patent suit is captured by a probability $\alpha$ that the disputed patent is valid and, thus the patentee prevails in the suit. This probability is assumed to be known and shared by both the incumbent and potential entrants. To focus on the main topic of our interest, namely, the information revelation aspect of patent suits, I assume away any legal costs involved in the litigation process. For simplicity I also assume that the outcome of the suit is determined immediately. There are two possible outcomes for the patent suit. If the entrant is found to infringe on the patent, a court injunction will prohibit the selling of the imitated product and consequently, the entrant should leave the industry forfeiting the entry cost of $F$. In this case, the incumbent will remain as a monopolist for the

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14If the uncertainty is about the exact boundary of patent breadth, $\alpha$ may be an endogenous variable that depends on the entrant's location choice in product space. Even though this possibility can be incorporated in the model, for analytical simplicity, I abstract from it by assuming that the technology of imitation allows the entrant to locate only at one specific point. See Waterson (1990) for a model of product patents where the entrant's variety choice is endogenously derived.

15It is possible that the patentee has better information regarding this probability since she may know the potential weakness of the patent (Meurer, 1989). In this case, the mere decision to bring a suit can have informational content, especially when out-of-court settlement is possible. This is an important agenda for future research. See Horstmann et al. (1985) for an analysis where the decision to patent can have a similar information-revealing effect.

16In Meurer's (1989) model, the incentive to avoid legal costs plays a crucial role to the settlement process of patent litigation. Meurer's and my papers, however, should be viewed as complementary rather than competing because they highlight different aspects of patent litigation. Josh Lerner (1995) empirically examines the effect of litigation costs on the patenting behavior of new biotechnology firms.

17In reality, few patent disputes are finally settled within three years (White and Jacob, 1986). In the case of Polaroid v. Kodak in which Polaroid received $985 million as a settlement, it took 14 years for the patent infringement suit to be resolved. One important topic for future research is to incorporate this empirical fact into the model.
period. The other possible outcome of the suit is that the patent is deemed to be invalid. If this is the case, the market will be occupied by two firms in the first period.

The main focus of this paper is the implication of the patent suit for the other entrant in period 2. At the beginning of the second period, another potential entrant arrives on the scene and makes his own decision regarding entry. He is assumed to have observed what happened in the first period. In particular, the outcome of the patent suit, if there was one, is known to him. There are four possible subgames facing the second potential entrant: (i) there was no entry in the first period, (ii) there was entry but it was accommodated by the patentee, (iii) there was entry and an infringement suit in which the patentee prevailed, and (iv) there was entry and a suit in which the patent was held invalid.

If he decides to enter, there may be another infringement suit by the patentee. However, for simplicity, I make the following observations/assumptions regarding the litigation process in the case that the first entrant is sued for infringement in the first period. If the patent is invalid, there is no patent and the other entrant can enter the market without the fear of being sued. If the patentee prevails in the first period, on the other hand, her competitors are assumed to respect the patent in the future even though,

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18 According to White and Jacobs (1986), “[a]ctions are brought to punish the infringer, to stop further infringement by him or others, to establish the legal position for the future; very seldom should they be brought for the sake of the damages.”

19 A third possibility I ignore is the case where the patent is valid but the claims of the patent specification are too narrow to cover the article the entrant is producing. In this case, everyone in the industry now knows how to get around it. Therefore, as will be clear, I can ignore this possibility without any loss of generality since, for my purposes, this case is equivalent to the one where the patent is found to be invalid.

20 This doctrine is called collateral estoppel which states that a patent owner is precluded “from asserting a charge of infringement if the patent has already been found invalid in earlier litigation involving its owner and a different accused infringer (Kintner and Lahr, 1975).” Monsanto v. Rohm & Haas Co., 312 F.Supp. 778 (E.D.Pa.1970) appears to be the leading case on this issue.
theoretically, they can challenge it again. I can relax this assumption without affecting the main results of the paper as long as other potential imitators update their beliefs in a way that reduces the expected value of imitation.

If the incumbent accommodates entry in the first period, there is a question of whether the previously accommodated entrant can be litigated with a delayed suit in the second period. This is due to the existence of a legal doctrine called "laches estoppel and the statute of limitations" (35 U.S.C.A. Sec 286). The purpose of this rule is to prevent a patentee from enforcing her patent against a party for infringement because she "slept on [her] rights while the infringer made expenditures in the belief that he was not infringing the patent or that, if infringing, he would not be sued [Kintner and Lahr (1975)]." If this legal doctrine is operative, the patentee cannot charge the previously accommodated imitator with patent infringement in the second period. In the United States, courts use the six year statute of limitations, that is, a delay in filing suit for more than six years is presumptively unreasonable and the burden shifts to the patentee to rebut the presumption.

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21In this respect, the doctrine of collateral estoppel does not work in reverse (Symbol Technologies Inc. v. Metrologic Instruments Inc., 771 F.Supp. 1390, 21 USPQ2d 1481 (D.N.J. 1991)). "An owner whose patent has been found valid in an initial suit against one infringer may not thereafter avoid relitigation of the validity of the patent in a subsequent suit against another infringer (Kintner and Lahr, 1975)."

22Courts ruled that a patent's presumption of validity is strengthened by a prior judicial determination of validity (Wang Laboratories Inc. v. Mitsubishi Electronics America Inc., 29 USPQ2d 1481, 1488 (C.D. Calif. 1993)). The rule is a special case of equitable estoppel which applies because of the patentee owner's earlier inaction. In Tracerlab, Inc. v. Industrial Nucleonics Corp., 204 F.Supp. 101, the district court of Massachusetts ruled that "[p]laintiff should have brought its action promptly when it knew its rights were being violated." The leading case for these issues is Gillions et al. v. Shell Co. of California, 86 F. 2d 600, 601 (CA-9). See Prestia (1978) for a detailed discussion of laches and estoppel in the delay of patent suits.

23However, delay in proceeding against the first imitator is no ground for refusing an injunction, if there has been no delay in proceeding against the second imitator. Therefore, the patentee can proceed against the second imitator even though she accommodated the first imitator and relinquished her rights for the remedy against the first imitator.
of prejudice (Bott v. Four Star Corp., 807 F2d 1567, 1 USPQ2d 1210, 1216 and Hottel Corp. v. Seaman Corp., 4 USPQ2d 1939, 1940).

The applicability of the doctrine of "laches estoppel" in the basic two-period model, depends on the length of the first period which is meant to be the time elapsed between the first and second entry. In the next section, however, I allow endogenous timing of entry in an infinite horizon model where I derive equilibrium entry patterns as the length of each period shrinks to zero. For the limit result with a short period length, it is much less reasonable to assume that delayed suits are not permitted by invoking the "laches estoppel" doctrine than it is in the basic two-period model. To keep consistency and facilitate comparison with the infinite horizon model, I shall therefore assume that the length of the first period is not long enough to make the doctrine applicable in the two-period model. As a result, I allow the incumbent to litigate the previously accommodated entrant in the second period.

With these assumptions, I observe that in the second period it is a dominant strategy for the incumbent to sue any entrant - both current and previously accommodated, as may be the case - since without any threat of further entry, the incumbent has nothing to lose by suing. However, it should be recognized that, in contrast, suing in the first period entails a serious risk for the patentee since it can facilitate further entry in the second period in case she loses. Note that in this model, even if the outcome of a delayed suit by the incumbent turns out to be the invalidation of the patent, the second potential entrant is not allowed to enter afterwards once it foregoes the

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25 I thank an anonymous referee for pointing this out to me.
26 In an earlier version of this paper, however, I derived essentially the same qualitative results as here under the alternative assumption that laches estoppel is applicable.
opportunity to do so at the beginning of the second period. This artificial assumption, which stems from the exogeneity of entry timing in a two period model, will, however, be relaxed in the next section.

The order of decisions and the payoffs are summarized in Figure 1. The subtree corresponding to the second period is collapsed to reflect the fact that litigation is a dominant strategy for the incumbent in the second period since there is no further entry even if she loses in the suit.

Figure 1 - The Order of Decisions and Payoffs: I, E1, E2, and C denote Incumbent, Entrant 1, Entrant 2, and the Court, respectively. The payoffs vectors list final payoffs for I, E1, and E2 in that order. The subtree corresponding to the second period is collapsed reflecting the fact that litigation is a dominant strategy for the incumbent in the second period since there is no further entry even if she loses in the suit.
Let us now analyze the game using a standard backward induction argument. Suppose that there was entry and a subsequent patent infringement suit in the first period. The second entrant will decide to enter depending on the outcome of the suit; he enters if and only if the patent has been deemed to be invalid. Alternatively, suppose that there was entry but no patent suit was brought by the patentee in the first period. Then, the second entrant should decide whether or not to enter under uncertainty about the outcome of patent suit. Given that it is a dominant strategy for the incumbent to file a suit in the second period, he will enter if and only if

\[(1-\alpha)\Pi^T - F > 0\]  

Let us now turn to the decision for the patentee in case of entry in the first period. If she brings an infringement suit, her expected payoff is given by:

\[W_S = \alpha(\Pi^M + \delta\Pi^M) + (1-\alpha) (\Pi^D + \delta\Pi^T)\]  

If she prevails in the suit, she will have monopoly profits in both periods since she has now deterred entry in the second period as well. If she loses, she will have duopoly profit in the first period and triopoly profit in the second period due to further entry. The discount factor \(\delta\) reflects the relative length of the first and second period. Consequently, I do not make any presumption on the magnitude of \(\delta\); it need not be less than 1 if the time horizon after the second entry is sufficiently long compared to the length of the first period, the time lapse between the first and second entry.

If the incumbent does not sue, she will have a duopoly profit in the first period. The profit in the second period depends on the entry configuration. Let \(\alpha_2^*\) be defined by:

\[(1-\alpha_2^*)\Pi^T - F = 0\]  

Then, \(\alpha_2^*\) is the smallest probability of the patent being valid that prevents second-period entry.\(^{27}\) If \(\alpha > \alpha_2^*\), i.e., condition (2) is violated, there will be no further entry. The

\(^{27}\)The subscript on \(\alpha\) refers to the firm for which the critical value is relevant in order to make an entry decision.
patentee will litigate the first entrant with a delayed suit in the second period, the expected payoff of which is $\alpha \Pi^M + (1-\alpha) \Pi^D$. If $\alpha < \alpha_2^*$, i.e., condition (2) is satisfied, then there will be entry in the second period if no litigation took place in the first period. The patentee will sue both the previously accommodated entrant and the new entrant in the second period. In this case, the second-period expected profit for the incumbent will be $\alpha \Pi^M + (1-\alpha)\Pi^T$. I can write the expected payoff of accommodating entry in the first period as:

$$W_A = \Pi^D + \delta [\alpha \Pi^M + (1-\alpha)\Pi^T] \quad \text{if } \alpha < \alpha_2^*$$

$$\Pi^D + \delta [\alpha \Pi^M + (1-\alpha)\Pi^D] \quad \text{if } \alpha > \alpha_2^*$$

If I rewrite Eq. (3) as $W_S = [\alpha \Pi^M + (1-\alpha)\Pi^D] + \delta [\alpha \Pi^M + (1-\alpha)\Pi^T]$, it is immediate that $W_S > W_A$ if $\alpha < \alpha_2^*$, there is no adverse effect of information revelation associated with the patent infringement suit since there will be a further entry anyway in the second period. If $\alpha > \alpha_2^*$, the condition for information concealment through accommodation to be a preferred strategy for the patentee is given by $\alpha < \alpha^{**}$, where $\alpha^{**} \in (0,1)$ is uniquely defined by:

$$[\alpha^{**} \Pi^M + (1-\alpha^{**})\Pi^D] + \delta [\alpha^{**} \Pi^M + (1-\alpha^{**})\Pi^T] = \Pi^D + \delta [\alpha^{**} \Pi^M + (1-\alpha^{**})\Pi^D]$$

There are two cases to consider depending on the relative magnitude of $\alpha_2^*$ and $\alpha^{**}$.

**Case I.** $\alpha_2^* > \alpha^{**}$.

In this case, $W_S > W_A$ for all $\alpha \in (0,1)$, implying that the incumbent patentee will always bring an infringement suit in face of initial entry. As long as there is entry in the first period in equilibrium (i.e., $\alpha$ is not too high to make the infringement almost certain), I obtain the predicted properties regarding each player's payoffs: The incumbent's profit is continuous and increasing in $\alpha$ and potential imitators' profits are continuous and decreasing in $\alpha$.

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Note that it is not allowed for the second entrant to enter if the outcome of the suit turns out to be the invalidation of the patent once he foregoes the chance to enter at the beginning of the period. This artificial assumption is relaxed in the next section.
Case II: $\alpha_2^* < \alpha^{**}$.

In this case, there exists a set of parameter $l = [\alpha_2^*, \alpha^{**}]$, which I call the "limit entry set." If $\alpha$ belongs to $l$, the first entry will be accommodated and there will be no further entry in the second period: $\alpha$ is sufficiently high to deter a further entry in the second period (i.e., $\alpha > \alpha_2^*$), but is too low for the incumbent to engage in a risky suit in the first period (i.e., $\alpha < \alpha^{**}$). The presence of the limit entry set generates interesting dynamics and produces many counter-intuitive predictions regarding the payoffs of players. Therefore, hereafter, I shall focus only on this case for the sake of brevity. Case I can be analyzed straightforwardly.

Finally, to characterize the first entrant's decision, I need another critical value, $\alpha_1^*$, which is defined by

$$
(1 - \alpha_1^*) (\Pi_D + 8\Pi_T) - F = 0
$$

The first entrant is indifferent between entering and staying out at the critical value $\alpha_1^*$ assuming the entry is responded to by an infringement suit. Note that $\alpha_1^* > \alpha_2^*$ implying that the first entrant has a bigger incentive to enter due to a longer horizon. The following proposition characterizes the equilibrium in the imitation game.

**Proposition 1.** Suppose that there exists a limit entry set $l = [\alpha_2^*, \alpha^{**}]$. Let $\alpha# = \max(\alpha_1^*, \alpha^{**})$. (i) If $\alpha < \alpha#$, firm 1 enters the market in period 1. Confronted with an entrant, the incumbent accommodates the entry if $\alpha \in l$. In the second period, there is no further entry and the patent will bring a delayed suit against the previously accommodated entrant. (When $\alpha#. = \alpha^{**} > \alpha_1^*$ and $\alpha \in (\alpha_1^*, \alpha^{**})$ there would be no entry in the first period if the incumbent were able to commit to bringing an infringement suit in the first period. However, this threat is not credible and consequently, there will be entry.) Otherwise (i.e., if $\alpha \in (0, \alpha#) - l$), she brings an infringement suit. Depending on the outcome of the suit, there may be further entry in period 2; firm 2 enters if and only if the patent is held invalid. (ii) If $\alpha > \alpha#$, there is no entry in either period. The expected equilibrium payoffs as a function of $\alpha$ are shown in Figure 2 (assuming $\alpha_1^* > \alpha^{**}$).
Figure 2 - The Expected Payoffs of the Incumbent and Entrants as Functions of $\alpha$. 
As can be seen in Figure 2, the payoffs for each player are discontinuous or kinked at the boundary of the limit entry set. Moreover, the imitators' payoffs need not decrease as the degree of patent protection, parametrized by $\alpha$, strengthens. As $\alpha$ increases and passes through the limit set, there is a fundamental change in the regimes. Despite this fact, the patentee's expected payoff is a weakly increasing function of $\alpha$. The reason is that the patentee always has the option of suing in the limit entry set. Moreover, the first entrant's behavior is not affected as $\alpha$ crosses the boundary of the limit entry set. However, this invariance of the entrant's behavior is due to the artificial assumption of exogenous entry timing. In the next section, it will be shown that if the timing of entry is endogenized, an increase in $\alpha$ can have a perverse effect on the expected payoffs of the incumbent.

### III. Endogenous Entry Timing in an Infinite Horizon Model

In this section, I relax the artificial assumption of exogenous entry timing. As before, there are two potential entrants indexed by $i=1,2$, who can now enter at any time they desire if they have not yet entered. Entry decisions are made only at the beginning of each period, the length of which is $\Delta$. In each period, if there is any entry, the patentee can respond with a patent suit if she chooses to. As before, per-period payoffs for monopolist, duopolist and triopolist are denoted by $\Pi^M, \Pi^D,$ and $\Pi^T$, respectively. The discount factor is given by $\delta = \exp(-r\Delta)$, where $r$ is the rate of interest. I now analyze the entry game played by two potential entrants as a simple stopping game in an infinite horizon model in which the decision of each firm is its time of entry.

In light of the results in the previous section, I define the limit entry set, $\mathcal{J} = [\alpha^*_2, \alpha^{**}]$, which corresponds to the infinite horizon. One implication of having no definite end period is that the threat of further entry is always felt by the patentee, which makes

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29 Once again, subscript 2 refers to the second entrant. In contrast to the previous section, the order of entry, however, is endogenously determined rather than exogenously fixed.
litigation risky, whenever there is only one entrant in the market. The boundary of the limit entry set, $\alpha^*_2$ and $\alpha^{**}$, are defined in the similar fashion, taking into account an infinite horizon.

\[
(1 - \alpha^*_2) \frac{\Pi^T}{\delta} - F = 0 \tag{4}'
\]

\[
\alpha^{**} \frac{\Pi^M}{\delta} + (1 - \alpha^{**}) \left[ \frac{\Pi^D}{1 - \delta} + \delta \frac{\Pi^T}{1 - \delta} \right] = \frac{\Pi^D}{1 - \delta} \tag{6}'
\]

Once again, I assume that $\alpha^{**} > \alpha^*_2$, ensuring that $\mathcal{I}$ is not empty. Since the existence of the set $\mathcal{I}$ is essential for the entry dynamics discussed above, it is appropriate to consider the plausibility of such a set. The examination of Eqs (4)' and (6)' reveals that $F$ (the sunk cost of entry) is a crucial determinant of $\alpha^*_2$. In contrast, $\alpha^{**}$ is purely determined by the relative magnitude of $\Pi^M$, $\Pi^D$, and $\Pi^T$. $F$ has no role in the determination of $\alpha^{**}$.

Therefore, for virtually all oligopolistic models conceivable, I can find values of $F$ that guarantee the existence of the limit entry set ($\mathcal{I}$) since $\alpha^*_2$ approaches zero as $F$ becomes sufficiently close to $\Pi^T$.\(^{30}\) In Cournot models with linear demand curve and constant marginal cost, for instance, it can be easily verified that $\alpha^{**} = 7/27$, as $\Delta \to 0$ (which is the case I analyze later). Hence, the set $\mathcal{I}$ is non-empty if $F/(\Pi^T/r)$ - the ratio of the sunk cost and the present discounted value of the triopoly profit - is larger than 20/27.

### A. Waiting Game Regime

Now suppose that $\alpha \in \mathcal{K} = [0, 1] - \mathcal{I}$, i.e., the best response of the patentee facing an initial entry is countering with an infringement suit. In this case, the expected payoff of the first imitator who enters in period $t$ can be written as:

\[
L(t) = \delta^{t-1} \left[ (1 - \alpha) \left( \frac{\Pi^D}{1 - \delta} + \delta \frac{\Pi^T}{1 - \delta} \right) - F \right] \tag{8}
\]

\(^{30}\)The only exception occurs if $\Pi^D = \Pi^T$ in which case I have $\alpha^{**} = 0$. However, this case is eliminated by the maintained assumption of $\Pi^D > \Pi^T$. In the case of Bertrand competition with homogenous product, I can have $\Pi^D = \Pi^T (= 0)$. But Bertrand competition is not appropriate to analyze the issue of patent protection because there would be no entry (imitation) even in the absence of any patent if there is a sunk cost of entry; patent is a redundant instrument in deterring entry.
If one firm enters in period $t$, the other firm can receive information regarding the infringement of the patent, which allows the latter's entry decision to be conditioned on the outcome of the suit. Therefore, the follower's expected payoff is

$$F(t) = \delta^{t-1} \left[ (1 - \alpha) \left( \frac{\Pi^F}{1 - \delta} - F \right) \right]$$  \hspace{1cm} (9)

If both firms enter in the same period, we know that it is a dominant strategy for the patentee to sue since there is no further entry to be concerned about. Therefore, the expected payoff of both entrants can be written as

$$B(t) = \delta^{t-1} \left[ (1 - \alpha) \left( \frac{\Pi^B}{1 - \delta} - F \right) \right]$$  \hspace{1cm} (10)

To make the initial entry feasible ($L(t) > 0$), assume that $\alpha < \alpha_1^*$, which is defined by

$$(1 - \alpha_1^*) \left( \Pi^D + \delta \frac{\Pi^F}{1 - \delta} \right) - F = 0$$  \hspace{1cm} (7)

The game is stationary before any entry and has a unique symmetric equilibrium, which is also stationary. As explained below, I am interested in the case where the time periods are short, i.e., $\Delta$ is small. In this case, it is easy to verify that the game exhibits the payoff structure of a waiting game. The equilibrium is characterized by mixed strategies in which each potential entrant enters with probability $p$ in each period if no player has entered before.\footnote{There are also two asymmetric stationary equilibria: one is that firm 1's strategy is "always enter" and player 2's is "never enter"; the other is one in which the roles of firms are reversed.} For the stationary symmetric profile $(p, p)$ to be an equilibrium, a firm should be indifferent to entering now and waiting for one more period. When the other player enters with probability $p$, the value of entering is given by:

$$V_{E}(p) = p \left[ (1 - \alpha) \left( \frac{\Pi^F}{1 - \delta} \right) \right] + (1 - p) \left[ (1 - \alpha) \left( \Pi^D + \delta \frac{\Pi^F}{1 - \delta} \right) \right] - F$$  \hspace{1cm} (11)

The value of waiting is

$$V_{W}(p) = p \left[ (1 - \alpha) \delta \left( \frac{\Pi^F}{1 - \delta} - F \right) \right] + (1 - p) \delta V$$  \hspace{1cm} (12)

where $V$ is the equilibrium value of playing the imitation game.
The equilibrium probability of adoption $p^* \in (0, 1)$ will be chosen so that $V_E(p^*) = V_W(p^*) = V$. For reasons of tractability, I shall focus on the equilibrium outcomes as $\Delta \to 0$. The consideration of periods with a shorter time interval also captures the notion that potential entrants can enter at any time they desire if they have not yet entered. To derive the limit results, it is convenient to approximate the waiting game with a continuous-time formulation. Then, the discount factor, $\delta = \exp(-r\Delta)$, reflects the time lapse between periods. I now interpret $\Pi^M$, $\Pi^D$, and $\Pi^T$ as flow profits for monopoly, duopoly and triopoly, respectively.

With the continuous time formulation, let $G(t)$ denote the cumulative probability that firm $i$ enters the market at or before $t$. For $G$ to be a stationary symmetric equilibrium, it is necessary that the players be indifferent to entering at time $t$ and waiting until $t + dt$ to take advantage of the information revelation created by the other entrant. Conditional on not entering before $t$, the marginal cost of waiting is approximated, to the first order of $dt$, by $\frac{(1-\alpha)\Pi^T - rF}{\alpha F} dt$. By waiting, one loses flow profits proportional to $dt$ should the patent be held invalid, which occurs with probability of $(1-\alpha)$. Since successful entry will be followed by another entrant immediately ($\Delta \to 0$), the relevant profit is a triopoly profit. The second term in the square bracket, $rF$, is a cost saving from deferred entry. The expected reward from waiting comes from the avoidance of fixed cost when the imitation is found to infringe the patent, which is $\alpha F dG$. Equilibrium requires that these two terms be equalized, which yields:

$$\frac{dG}{1-G} = \frac{(1-\alpha)\Pi^T - rF}{\alpha F}$$

(13)

The equilibrium strategies are characterized by an exponential distribution with a parameter of $\lambda = \frac{(1-\alpha)\Pi^T - rF}{\alpha F}$. Let $\tilde{T}$ denote the first entry time, which is random. Then, the incumbent has a monopoly profit until $\tilde{T}$, thereafter her expected payoff is

\[32\text{It can be formally demonstrated that this equilibrium in continuous strategies is the limit of the equilibrium of the corresponding game in discrete time as } \Delta \text{ goes to zero. To make the discrete- and continuous-time formulations comparable, I have to assume that the profits for monopolist, duopolist, and triopolist are } \Pi^M, \Pi^D, \text{ and } \Pi^T \text{ per unit of real time, respectively. For instance, the monopoly profit in discrete time with period length of } \Delta \text{ is } \Pi^M \Delta. \text{ See Fudenberg and Tirole (1991) for details.}\]
triopoly profits if the patent is held to be invalid:

\[ W = \alpha \frac{\Pi^M}{r} + (1 - \alpha) E \left[ \int_0^T \Pi^M e^{-rt} dt + \int_T^\infty \Pi^T e^{-rt} dt \right] \]  

(14)

Since \( \tilde{t} \) is the first-order statistic corresponding to a random sample of size 2 from an exponential distribution with a parameter \( \lambda \), I can write

\[ E(e^{-\tilde{t}}) = \frac{2\lambda}{r + 2\lambda} \]  

(15)

Thus the expected payoff for the incumbent is

\[ W = \alpha \frac{\Pi^M}{r} + (1 - \alpha) \left[ \frac{\Pi^M}{r + 2\lambda} + \frac{2\lambda\Pi^T}{r(r + 2\lambda)} \right] \text{ where } \lambda = \frac{(1 - \alpha)\Pi^T - rF}{\alpha F} \]  

(16)

By definition of \( \alpha_2^* \), I have \( \lambda \rightarrow 0 \) as \( \alpha \rightarrow \alpha_2^* \). Consequently, the expected payoff for the incumbent approaches the monopoly profit \( \Pi^M/r \) as \( \alpha \rightarrow \alpha_2^* \).

**B. Preemption Game Regime**

Now suppose that \( \alpha \in \mathcal{L} \). For this parameter region, if in period \( t \) there is only one entrant, he will be accommodated whereas further entry is deterred. Therefore, the expected payoff of the first player who enters in period \( t \) can be written as:

\[ L(t) = \delta^{t-1} \left( \frac{\Pi^0}{1 - \delta} \right) \]  

(17)

The other player gets zero. If both potential entrants enter in the same period \( t \), the expected payoffs of both players are given by Eq. (10) as before.

The game is one of preemption where each firm strives to be the first entrant knowing that he will be accommodated without further entry. The game has a unique symmetric equilibrium. In each period, if no entry has yet occurred, each player enters the market with probability \( p \) which is given by:

\[ p = \frac{\Pi^0 - (1 - \delta)F}{\Pi^0 - (1 - \alpha)\Pi^T} \]  

(18)

The expected payoffs of both players are zero. The reason is that there is a positive probability of coordination failure: both enter in the same period and lose \( B(t) \) which is negative when \( \alpha \in \mathcal{L} \). I note that \( \partial p/\partial \alpha < 0 \). The reason is that potential entrants become
more cautious in their entry decision as the expected cost of mistakes (i.e., coordination failure) for them increases with \( \alpha \).

The continuous time formulation of the preemption game involves a subtlety that is not present in the waiting game since the formalization that is applied to a waiting game "entails a 'loss of information' in passing from discrete time with short periods to the continuous time limit" [see Fudenberg and Tirole (1985) for a new formulation that allows a continuous-time representation of the limits of discrete-time counterparts and discussions therein]. However, for my purpose, I need not delve into these technicalities. Let it suffice to mention the following features of the equilibrium as \( \Delta \to 0 \):

First, the entry game ends with probability 1 at time zero. Second, let \( \beta \) denote the limiting value of the probability of the coordination failure in the form of simultaneous entry. Then, I can write the expected payoff of the patentee as:

\[
W = \beta \left[ \frac{\alpha \Pi^M + (1-\alpha)\Pi^T}{r} \right] + (1-\beta) \frac{\Pi^D}{r}
\]  

(19)

I note that \( \beta = \frac{p}{2-p} \), which is decreasing in \( \alpha \):

\[
\frac{d\beta}{d\alpha} = \frac{\partial \beta}{\partial p} \frac{\partial p}{\partial \alpha} < 0
\]

(20)

An increase in \( \alpha \) reduces the probability of entry in every period for each entrant, which in turn reduces the probability of coordination failure (simultaneous entry).

Within the limit entry set, I can verify that the patentee's expected payoff increases as \( \alpha \) increases.\(^{34}\)

\[
\frac{\partial W}{\partial \alpha} = \frac{d\beta}{d\alpha} \left[ \frac{\alpha \Pi^M + (1-\alpha)\Pi^T}{r} - \frac{\Pi^D}{r} \right] + \beta \left( \frac{\Pi^M - \Pi^T}{r} \right) > 0
\]

(21)

This happens for two distinct reasons. First, as \( \alpha \) increases, the probability of coordination failure decreases (\( \frac{d\beta}{d\alpha} < 0 \)). Within the limit entry set, better coordinated entry induced by a higher \( \alpha \) is also beneficial for the incumbent because she prefers an accommodated

\(^{33}\)Technically, the set of continuous-time equilibria is not the set of limit points of discrete-time equilibria. \(^{34}\)I can also verify that \( W \) is a concave function of \( \alpha \) \((\frac{\partial^2 W}{\partial \alpha^2} < 0)\).
duopoly situation to a contested monopoly (the expression in the curly bracket in Eq (21) is negative when \( \alpha \in \mathcal{I} \)). Second, given the probability of coordination failure, a higher \( \alpha \) translate into a higher probability of maintaining monopoly position through litigation.

I can also show that as \( \alpha \to \alpha_2^* \), the cost of a mistake becomes closer to zero, inducing each potential entrant to enter almost surely in each period (\( p \to 1 \)). As a result, the probability of coordination failure also approaches one (\( \beta \to 1 \)) with the expected payoff of the incumbent being \( [\alpha \Pi^M + (1-\alpha)\Pi^T]/r \). I can conclude that due to a change in the nature of entry dynamics (infinite delay vs. immediate entry), the expected payoff of the incumbent jumps down discontinuously at the left boundary point of the limit entry set as depicted in Figure 3. In contrast, at the right boundary point of the limit entry set, the payoff jumps up to the monopoly profit level as the credibility of patent litigation is restored and entry is blockaded.

I note that \( \alpha_1^* \to \alpha_2^* \) as \( \Delta \to 0 \), which allows us to suppress the subscripts hereafter. Proposition 2 summarizes the equilibria that appear as limits of equilibria in a sequence of discrete-time, infinite-horizon games as \( \Delta \to 0 \).

**Proposition 2.** Suppose that there exists a limit entry set \( \mathcal{L} = [\alpha^*, \alpha^{**}] \).

(i) If \( \alpha < \alpha^* \), there is delay in the first entry, the timing of which is distributed exponentially with parameter \( 2\lambda \), where \( \lambda = \frac{(1-\alpha)\Pi^T - rF}{\alpha F} \). The incumbent brings an infringement suit in face of the first entrant. Depending on the outcome of the suit, there may be a further entry, firm 2 enters if and only if the patent is held invalid. (ii) If \( \alpha \in \mathcal{L} = [\alpha^*, \alpha^{**}] \), there is an immediate entry. If there is only one entrant, the incumbent accommodates the entry and there is no further entry. If both were to enter at the same time, the incumbent brings infringement suits. (iii) if \( \alpha > \alpha^{**} \), there is no entry. If there were entry, there would be patent litigation. The expected equilibrium payoffs as a function of \( \alpha \) are shown in Figure 3.
One important consequence of this proposition is that the strengthening of intellectual property rights (captured as an increase in $\alpha$) is not necessarily desirable for the patentholder. This raises the possibility that the innovator may try to reduce $\alpha$ by being intentionally sloppy in the patent application process. However, this strategy may backfire because it also reduces the probability that the application is granted a patent to begin with. Another way to reduce $\alpha$ by the pateneree is to proceed less aggressively in the court. However, this is not a credible strategy that can be precommitted; once an entry occurs, the patentee's (ex post) payoff always increases with $\alpha$. A lower $\alpha$ can be beneficial only in terms of the ex ante expected profit before any entry occurs.

I thank Paul Klemperer for raising this issue.
investment by providing better protection for the innovator may have the opposite effect of retarding the speed of initial innovation.

The result is reminiscent of Bernheim (1984) and Benoit (1985). In a model of sequential entry, Bernheim (1984) demonstrates that the qualitative nature of the entry deterrence decision undertaken by incumbent firms is much different from the single entrant case. One implication of his analysis is that the sequential aspects of entry deterrence makes it possible for government policies designed to promote entry to have the opposite effect of increasing industrial concentration. The reason is that the profitability of potential entrants is in turn determined in part by the ease with which future entrants can be deterred.

The nonmonotonicity of comparative statics result in both Bernheim's (1984) and my paper rely on the existence of multiple potential entrants. Despite the similarities in this regard, there are also some crucial differences between the two papers. First of all, Bernheim's (1984) model is devoid of any intertemporal aspects. His concern is with the equilibrium number of firms (industrial concentration) associated with the zero profit entry condition prevailing under various entry-deterrent strategies. In contrast, my model has a bite only when intertemporal aspects are considered: the driving force behind the nonmonotonicity result is generated through the endogenized timing of entry arising from the incentives to free-ride on information revelation created by the rival firm's entry or to preempt the rival firm in the imitation game. Second, potential entrants in Bernheim's model are symmetric in any ex post entry configurations, whereas potential entrants in my model can have asymmetric payoffs ex post when the initial entry has a preemptive nature or reveals new information regarding the validity of the patent.

36It is also worth mentioning a recent paper by Helpman (1993) which analyzes the enforcement of intellectual property rights in a dynamic general equilibrium framework of international trade in which the North invents new products and the South imitates them. In his model, tightening of intellectual property rights can hurt the North due to the effect of reallocation of production. When the initial rate of imitation is sufficiently low, the loss from this effect outweighs the gains from the terms of trade effect.
Benoit (1985) is closer to this paper in that the effect of imitation on the innovator is generated through *endogenized* entry timing of the imitator. In his paper, there is uncertainty surrounding the profitability of innovation, which is revealed only over time. This creates an option value of waiting for the imitator; even though the waiting strategy entails the loss of temporary profits in the event the innovation is favorable, it can save on a would-be failed investment. The difference is that a new flow of information arrives *exogenously* in Benoit's model, whereas in my model new information is created *endogenously* only when an action is taken by one of the parties concerned. In this respect, the delayed entry in my model is due to the strategic option value of waiting which is nonexistent in Benoit's model of a single entrant.

It is worthwhile to point out that the entry dynamics predicted in my model is in sharp contrast to the entry games considered by Milgrom-Roberts (1982) and Kreps and Wilson (1982). In their reputation model with multiple threats of entry, the incumbent predates early entrants to create and maintain a reputation for "toughness," which signals to other potential entrants that their chance of facing predation is more likely in the event of their own entry. However, once entry is ever accommodated, the type of the incumbent is revealed to be "soft" and entry occurs in every period thereafter. Therefore, accommodating one entrant but no more is never an outcome in such reputation models of entry deterrence. In my model, in contrast, predating the first entrant with litigation may result in the invalidation of the patent and induce further entry whereas accommodating the first entrant maintains uncertainty about the validity of the patent and thus can deter the second entrant who has to make his entry decision in the dark.

My model may also help explain the apparently puzzling practice of delaying patent suits despite the prevailing presumption that patent litigation is ruthlessly wielded as a

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*37* Benoit's model also predicts the nonmonotonicity of innovator's profit in relevant parameters (cost of innovation and probability of success) if imitation is possible.

*38* Another difference is that Benoit (1985) considers nonpatentable innovations, whereas my analysis applies only to patentable innovations.

*39* I am grateful to Co-Editor R. Preston McAfee for making this observation.
weapon of predation by the patentee at the first detection of infringement (Lanjouw and Lerner, 1996). In Baker Manufacturing Co. v. Whitewater Manufacturing Co., for instance, Baker gave notice in 1956 to Whitewater of its claimed infringement, but the suit was not commenced until 1965, a period of more than nine years (see also Prestia [1978] where dozens of delayed patent suit cases are discussed). In a more recent case, Texas Instruments sued five companies for infringement on its plastic encapsulation technology which enables wires to be connected to a semiconductor on a leadframe by introducing “fluid plastic.” The suit was not brought until 1990 even though the technology in dispute was developed in the 1970s and had been used for years by the rival firms (New York Times, July 10, 1990). The delay is especially puzzling in view of “laches estoppel” which may prevent the patentee from suing if she does not bring the suit promptly after imitation. This consideration impels White and Jacob (1986) to recommend that “the right time to start an action for infringement (if an action is to be started at all) is when infringement first starts - or even better, when infringement is first threatened.”

In my model, the reason for delay, despite running the risk of laches estoppel, can be found in the recognition of the potential downside of bringing a patent suit, that is, the validity of the patent may be revoked. This risk can be substantial if there are other

40 The five defendant companies named in the suit are Analog Devices, Cypress Semiconductor Corporation, VLSI Technology Inc., Integrated Device Technology Inc., and LSI Logic Corporation.

41 In response to the opponent firms’ contention that the patent was old, unimportant, and invalid, Richard Agnich, general counsel for TI, rationalized TI’s sudden utilization of litigation by saying “The other companies are reacting as a person would if he were told he would have to pay to use a lawn mower he had been borrowing from a neighbor for years. The person would get angry, but no one would question the right of the lawn mower owner to ask for payments or stop lending the mower.” (New York Times, October 16, 1990).

42 White and Jacobs (1986, p. 7) also cite other reasons that favor a quick patent infringement suit for the patentee. “If an infringer is allowed to infringe in peace for years - to spend money advertising a new business or a new product ... - he may well feel that there is so much at stake that he must fight; yet if the action had been brought earlier on, before there was so much at stake, he would probably have dropped the thing and cut his losses rather than waste time and money fighting.”

43 One common reason often offered to excuse the delay is that plaintiff’s financial condition did not permit it to undertake a costly suit. However, the court stated categorically that “lack of funds is no excuse for delay in bringing suit” (Whitman v. Walt Disney Prods., Inc., 148 F. Supp. 37. 112 U.S.P.Q. 220, (S.D. Cal. 1957)).
Potential entrants who can free ride on an outcome of invalidity and put the patentee in a worse position than when she started the lawsuit [Kintner and Lahr, 1975]. In fact, some industry observers attribute Texas Instruments' litigation strategy to the fact that Texas Instruments is no longer the dominant player in the industry. This is consistent with my model, which predicts that delayed suits will occur with the fragmentation of the industry as more firms enter the market.

In my two-period model, delayed suits occur as a part of the equilibrium behavior of the patentee. In the infinite horizon model, delayed suits constitute off-the-equilibrium punishment strategy even though they do not occur along the equilibrium path. There are, however, at least two ways to modify the infinite horizon model to account for the occurrence of delayed suits in the real world. First, the addition of private information would make the off-equilibrium punishments arise, which is accommodating the entry of one firm, then bringing suit to stop further entry. If the patentee has private information about the validity of the patent (i.e., $\alpha$), a low-type patentee with $\alpha < \alpha^*$ may have an incentive to pretend to be a high type with $\alpha \in I = [\alpha^*, \alpha^{**}]$ by accommodating the first entrant. In this case, we may see a mixed strategy equilibrium in which the first entrant is accommodated until further entry while the second one, whose entry triggers a delayed suit, enters with a random probability. Second, I have assumed a stationary environment, in particular, a constant $\alpha$ over time. In reality, however, this probability can change over time with the public sentiment and the basic attitude of the courts towards patents. For instance, in 1982 Congress passed the Federal Courts Improvement Act, creating the new Court of Appeals for the Federal Circuit (CAFC) which hears all appeals from the federal district courts involving patents. The result of this pro-patent institutional change has been a dramatic increase in the probability of patents being held valid, which made an

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45I thank R. Preston McAfee for pointing out this possibility. In Stryker Corp. v. Zimmer, Inc., 741 F. Supp. 509, 17 USPQ2d 1945 (D.N.J. 1990), the patentee did not enforce the patent against anyone for ten years despite "industry-wide infringement" and sued the accused infringer once it entered its market.
injunction against an infringer much more likely (Merges, 1992). Consider an initial situation (before the creation of CAFC) where \( \alpha \in I = [\alpha^*, \alpha^{**}] \), with initial entry having been accommodated. If the creation of CAFC raised the probability \( \alpha \) beyond the boundary of \( I \) (i.e., \( \alpha^{**} \)), the previously accommodated entrant would now be litigated, which results in a delayed suit. Another possibility is an advent of a new product that can render the patented product obsolete. Consider a situation where a new product is expected to be introduced in the near future as a result of an unexpected technological breakthrough. If the remaining life-cycle of the patented product does not justify the sunk cost of entry, there would be no more entry even if the patent is invalidated in the suit. This change in the competitive environment may induce the patentee to bring a suit now in the hope of securing the monopoly position for the rest of the life-cycle.

Finally, our analysis has important ramifications for the interpretation of empirical data on imitation. Mansfield, Schwartz, and Wagner (1981) for instance estimate that about 60 percent of the patented innovations in their sample were imitated within four years. The analysis of Mansfield et al. (1981) is based on the (implicit) premise that the imitation process itself is a race among potential imitators. Our analysis suggests caution in interpreting empirical data on imitation times, the data can overestimate the difficulty of imitation since the time lag may contain a component of strategic waiting.

IV. Concluding Remarks

I have developed a simple model of imitation with multiple entrants. The basic premise of the paper is that an initial imitation attempt and its accompanying patent infringement suit can serve as an information transmission mechanism in that other potential entrants can condition their own entry decisions on the information revealed through the patent suit. This informational externality can induce each potential entrant to

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46 "This court (CAFC) has been actively pro-patent; issued patents are treated as born valid, and infringement is a serious trespass (Inside R&D, October 10, 1990)."
wait for others to take the initiative, i.e., the imitation game is a waiting game. However, this is not the only possibility. There are also cases where the so-called "limit entry set (L)" exists. In these cases, if α ∈ L, the first entrant is accommodated whereas further entry is deterred. As a result, the nature of entry dynamics exhibits the payoff structure of a preemption game in which each one strives to be the first entrant. This implies that as parameter α changes and crosses the boundary of set L, the imitation game undergoes a fundamental change in the nature of entry dynamics. In fact, it was demonstrated that the expected payoff of the incumbent jumps down discontinuously at the left boundary point of L as the imitation game is converted from one of waiting to one of preemption; the timing of entry changes from infinite delay to immediate entry. Implications for the interpretation of empirical data on imitation were also discussed.

The model adds an important dimension to the innovation literature by considering the litigation process in the enforcement of patents. However, the model abstracts many important details of reality and leaves many questions unanswered. I conclude by mentioning several avenues along which the current analysis can be extended.

First of all, I have assumed that there is only one way to design around the patented invention. Realistically, there are many ways to invent around a patent, each with their own probability of infringement. Tradeoffs facing the imitator in the choice of imitative research strategy would be between a lower probability of infringement vs. a higher cost of inventing around. In other words, the probability of infringement can be reduced by spending more on searching for less obvious ways of inventing around the patent. I can think of the imitators' strategy as a choice of infringement probability. In this case, imitation efforts can create another public good since the benefit of successful imitation is shared by everyone else while the cost is borne by the first imitator. From the perspectives of potential imitators as a team, the noncooperative equilibrium choice of infringement probability would be suboptimally high.
A more serious deficiency of the current paper is that it does not allow for the possibility of the out-of-court settlement between the patentee and the accused infringer. In fact, a large proportion of infringement suits are settled out of court in the form of licensing (White and Jacob, 1986). An important question in this case is what kind of informational implications the out-of-court settlement entails. It is expected that the extent of information transmission is greater through trials than through the out-of-court settlement since the latter deprives other potential entrants of the opportunity to uncover critical information regarding the profitability of their own entry [Che and Yi (1990)].

My model thus suggests that settlements with potential patent-infringers may be motivated by other than the standard explanation of the avoidance of costly litigation, namely, information concealment reasons. In United States v. Union Camp Corp. (1969 Trade Case), for instance, the government brought criminal and civil proceedings against Union Camp which settled a patent dispute with a potential infringer in order to prevent the possible disclosure of information that could have proven Union Camp’s patent invalid.

If there is private information held by either disputing parties regarding the validity of the patent, litigation behavior in the court can have signaling value and potentially influence the terms of licensing as predatory behavior of the incumbent can affect the terms of merger with the entrant [Saloner (1987), Meurer (1989)]. Another discrepancy with reality is that I have assumed a timeless trial. However, protracted legal battles can be strategically used by the incumbent to retard the speed of further entry. On-going

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47Friendly settlement of law suits between rivals may induce inherently invalid patents to remain in effect to the date of expiration, resulting in restraint of trade.
48There are some jurists in the patent law area who are aware of the social costs of the settlements which preserve invalid patents and thus are unwilling to enforce the settlement of patent suits that raise the issue of validity. “The settled litigation might, if continued, have invalidated the patent and thus eliminated the patentee’s monopoly toll upon society (Areda, 1981).” For an analysis of the effect of litigation settlement on collusion in the federal agency procurement bidding, see Marshall et al. (1994).
50Burns (1986) estimates that predatory pricing significantly reduced the acquisition costs of American Tobacco Company both for victims of predation and, through reputation effects, for competitors who sold peacefully.
uncertainty about the outcome of litigation can leave other potential imitators' entry decisions in limbo, thereby allowing the incumbent extra time to come down along the learning curve.\textsuperscript{51}

Finally, my analysis has been limited to the post innovation incentive to imitate. It is important to embed my analysis in the overall innovation game. For instance, it is not an unreasonable assumption that the participation in the initial patent race can reduce the cost of imitation after the race is lost. Then, the progress made by the losers in the innovation race can position the imitators asymmetrically in terms of their ability to successfully invent around the patent. A full analysis of this possibility awaits future research. I believe, however, that none of the extensions mentioned above will alter the basic intuition of the paper.

\textsuperscript{51}Levin et al. (1987) report that the effectiveness of lead time and learning curve advantages was consistently rated high by high-level R&D managers among alternative means of appropriating the returns from R&D.
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