Litigation and Settlement in Patent Infringement Cases

Claude Crampes* and Corinne Langinier†

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Abstract

A patent is not a perfect protection against imitation. It grants the right to sue intruders once they have been identified. In order to identify an infringer, a patentholder has to monitor his market by his own, and then he has to react in case of infringement. His reaction may be to go to court, to settle an arrangement or to accept the entry. We investigate how intensive should be the monitoring effort and how the reaction of the patentholder may influence the entry decision. In a simultaneous game we show that even if the penalty paid by the infringer and the settlement cost are high, the patentholder may decide to choose a settlement instead of a trial. Furthermore, the likelihood of entry increases with the penalty for certain values of the parameters. If monitoring expenditures and entry are sequential, whatever the decision order entry occurs less often than in the simultaneous setting.

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*GREMAQ and IDEI, Université des Sciences Sociales de Toulouse.

†Concordia University, Montreal.

Résumé

Un brevet ne protège pas parfaitement contre les imitations. Il garantit le droit de poursuivre les coupables d'infraction quand ils sont identifiés. Mais le titulaire du brevet peut aussi tolérer l'entrée d'un imitateur ou passer avec lui un accord de licence. Cet article présente un modèle décrivant les équilibres entre les dépenses de surveillance du marché par un titulaire de brevet et la décision d'entrée d'un imitateur potentiel. Les équilibres sont paramétrés par le coût de négociation entre les deux agents et la pénalité infligée à l'imitateur en cas de condamnation. On étudie successivement le jeu simultané dans lequel l'effort de surveillance du titulaire et la décision d'entrée de l'incitateur ne sont pas observables par l'autre partie, puis les deux jeux séquentiels dans lesquels une partie connaît la décision de l'autre avant de prendre la sienne.

1 Introduction

Patent protection is usually viewed by economists as a device to promote innovation. Lawyers use to justify patents by a simple backward argument: innovators deserve at least to recoup their R&D expenses, and patents are a good tool to do it. By contrast, economists insist on the incentive feature of patent that is forward-looking: the innovator will direct his R&D efforts to the markets made most profitable by patents. The problem with the prospective viewpoint is that a patent becomes more than a mere reward for the innovation activity. Among others, it also rewards high performance in production and marketing. With the same patent, two different firms could obtain different benefits because they have different production and merchandising capabilities[1].

But this point of view is still too narrow because a patent is not a perfect protection against entry. It merely grants a right to sue intruders. If the patentholder cannot observe infringement or if he cannot identify the infringer, or if enforcement is too costly, the patent is undermined. This means that the value of a patent strongly depends both *ex ante*, when constructing the patent claims, and *ex post*, when enforcing them, on the competency of the innovator's legal department or on the quality of external legal advisers[2]. It results that while patents are typically

[1] This explains why a good innovator/bad developer has strong incentives to license his innovations.

[2] "Unless one is willing to sue on it, a patent is virtually useless, just a fancy piece of paper with a gold seal that looks good on the wall" (H.L. Speight, The National Law Journal, Monday, June 22, 1998).

viewed in the economic literature as a perfect exogenously given protection against imitation[3], their efficiency depends on the intrinsic characteristics and on the effort of the patent owner in trial and settlement procedures. They are mere property rights, effective only when they can be defended against intruders without dissipating so much profit that the defense would not be profitable.

When an innovator applies for a patent, there is some probability that one or several firms active in the market will try to impede him from monopolizing a fraction of this market. This means that patent-invalidity suits are one possible consequence of patent applications and they can be dissuasive for candidates to patent. In this paper, we do not analyze this issue. We rather limit our study to patent infringements, that is to situations where the roles are reversed as compared to "invalid patents": the owner of the property rights is the patentholder and consequently, he can sue any newcomer[4].

By contrast with most economic papers on patents that focus on the *ex ante* decisions of R&D processes (how much to invest in research or development?, is it worth to apply for a patent?, should the patent claims be for narrow or wide applications? etc.) we consider the case of a firm that is already a patent owner, and we deal with the following *ex post* problems: how intensive should be the market surveillance of patented markets and what is the best reaction to infringement? Indeed, the monitoring effort is all but routine. "By day, dressed in business suits, Flack and Whybrow (two very famous fraud investigators) posed as "procurement agent" seeking drug samples from suspect manufacturers; the samples would then be analyzed to see whether patents have been violated. By night the really dangerous work began: The pair would don dark clothes and leap over factory walls -taking photographs, rummaging through garbage bins, ripping labels off containers, and sometimes even entering the plants themselves" (Fortune, Drug Spies, September 6, 1999). Even if this is an extreme case of monitoring, and almost failing to keep within the law, it shows how important monitoring is.

In this paper, we first consider a simultaneous game in which a patentholder and a potential infringer decide respectively the intensity of the monitoring and whether or not to enter the protected market. If imitation occurs, the patentholder has some chances to establish the

[3]Gallini (1991) is an exception since she explicitely models the possibility of imitation. Note also that patents can have adverse effects: by signalling market profitability, they can increase the probability of entry instead of reducing it (see Crampes and Langinier (1998)).

[4]Meurer (1989) analyses patent licensing in the settlement of litigation when the patent is not valid for sure. We compare Meurer's model with ours at the end of section 2.

identity of the infringer as a result of his surveillance effort. If he identifies the infringer, the patentholder can choose between several options; he may decide to sue the infringer, to try to reach a settlement or eventually to abandon any pursuit and let the infringer be in the market. Each of these outcomes will lead both firms with different payoffs, but in any case it is costly: to let the infringer be in the market reduces market power, to go to court involves trial expenses, and some adverse marketing effects; finally to settle an arrangement involves settlement cost and some risks to be accused of collusion. We define different types of equilibria, depending on the cost of settlement and on the penalty for infringement. While we use standard non cooperative game theory to model the entry decision and the monitoring decision, we adopt the Nash bargaining solution to obtain the outcome of the settlement process.[5] We find that for a high level of penalty as well as a high cost of settlement, the patentholder prefers a settlement to a trial. Furthermore, the likelihood of entry increases with the penalty for certain values of the parameters.

Then, we consider two mutually exclusive sequential games. In the first game, the patentholder takes his monitoring decision first while in the second game the infringer decides to enter or not first. In these sequential games entry occurs less often than in the sequential game.

The paper is organized as follows. In section 2, we present the hypotheses and the timing of the model. In section 3 we analyze the equilibria of a simultaneous game where the patentholder decides how much to spend in *ex post* monitoring activities while a challenger decides to enter or not the protected market. Section 4 includes a graphic illustration and a discussion of variations in the parameters underlying the simultaneous game. In section 5, we consider the effects of sequentiality: we first assume that the challenger knows the monitoring effort of the incumbent before deciding on entry and, second, we analyze the opposite timing. Section 6 concludes.

2 Model setting

We consider two players, labeled h for the patentholder and i for the potential infringer. At the beginning of the game, an innovation has already been patented and the problem of the owner

[5] For a survey concerning the economic analysis of legal disputes in general framework see Cooter and Rubinfeld (1989). Aoki and Hu (1999a, 1999b) have also developed a Nash Bargaining model of patent litigation with imperfect enforcement and they analyze the different rules of damage reward: the British rule that obliges the losing party to pay the attorney's fees of the other party vs. the American rule where this payment is due only in case of willful infringement.

is to decide whether to invest in an effort for detecting the possible entry of an imitator and identifying her. Let $x \geq 0$ be the watch effort and $p(x)$ the probability for the patent owner to identify the imitator when entry has occurred. We consider that the incumbent always detects an entry because he can observe a decrease in his profits due to the presence of a competitor. But detection is not enough for a settlement or a lawsuit. In order to propose a settlement or to threat an entrant to go to court it is necessary (i) to establish the identity of the infringer, (ii) to check the validity of the patent and (iii) to check whether there are meaningful arguments of infringement. All these expenditures are summed up in the "monitoring effort" x. If no entry has occurred (denoted by $e = 0$), the patentholder earns monopoly profits π_m^h and the challenger receives 0. If entry has occurred ($e = 1$), the infringer has still some chances not to be identified by the property-right holder with probability $[1 - p(x)]$. We assume that $p'(x) > 0$, $p''(x) < 0, p(0) > 0$ and $p(\bar{x}) = 1$.

When the patentholder identifies the imitator and thinks he can claim for infringement, he considers one of the three following endings:

(R) "renunciation solution": to accept the entry without any reaction;

(S) "settlement solution": to come to some kind of arrangement with the entrant;

(T) "trial solution": to sue the infringer at law.

Except in case (T) when the plaintiff succeeds in obtaining an injunction requiring the infringer to stop making and selling the product based on the patented innovation, the resulting market structure is a duopoly. In case (R), the gross profit of the incumbent is $\pi_d^h \leq \pi_m^h$ and the entrant obtains a net profit equal to π_d^i. If the challenger markets a product highly differentiated, it is quite possible to have π_d^h close to π_m^h despite $\pi_d^i > 0$. On the contrary, with an imitator selling a close substitute in the same market, we obviously have $\pi_d^h + \pi_d^i < \pi_m^h$.

Consider now "the trial outcome" (case (T)): the patentholder decides to go to court when the imitator is identified. This solution has several drawbacks[6]. First it can be a bad publicity for both firms. Most managers and shareholders prefer to see the name of their firm or brand in the business newspapers rather than in the Police Gazette. For this reason, we can assume that the profit from market in the trial case is on the average $\tilde{\pi}_d^h$ for the incumbent and $\tilde{\pi}_d^i \leq \pi_d^i$ for the

[6] For an econometric analysis of the determinants of litigation to resolve disputes on patents, see Lanjouw and Schankerman (1998), and Lanjouw and Lerner (1997) for a survey of the empirical literature.

entrant[7]. The second inconvenient is that a trial is costly and risky. The plaintiff cannot be sure from the very beginning whether the defendant will be condemned[8]. To insist on the reluctance of the patentholder to go to court, we assume he is risk averse with an absolute risk aversion coefficient equal to β'. Consequently, if F_t^h stands for the expected net compensation received by the plaintiff (gross compensation minus lawyers' retainer and proceeding expenditures) and if σ^2 is the variance of this compensation, $\tilde{\pi}_d^h + F_t^h - \beta\sigma^2$ where $\beta = \beta'/2$ is the net payoff of the patentholder when choosing the trial solution.[9] By contrast, we assume a risk neutral infringer so that her payoff is $\tilde{\pi}_d^i - F_t^i$, where $F_t^i (\geq F_t^h)$ is the expected fine to be paid in the trial case. But obviously a trial can have valuable advantages for the plaintiff: for instance, a judicial condemnation of the patent violator allows to stop unfair competition, to gain damages[10], but also to reduce drastically the risks of future infringement by designing around the patent.

Finally, the patentholder can propose the infringer a settlement (case (S)), that is in most cases, a license contract allowing to share the benefits derived from the use of the patented innovation. We assume that such an initiative is costly for the patentholder because of the preparation of the technical files, some likely adaptation of the innovating process or product,

[7]These profits represent in fact the expected discounted payoffs in case of a trial. Indeed, if the patentholder wins the case, he may have a new monopoly position if the infringer has to exit the market. In order to keep the model as simple as possible, we just assume that the expected discounted payoffs will be smaller than the monopoly payoffs without giving a precise specification.

[8]For the patent owner, uncertainty on the benefits of a trial can have many origins. First, it could appear that the patent is not (or no longer) valid. Second, "launching an infringement suit may be a risky proposition for the patentee because of potentially harmful information that can be exposed in the litigation process. In particular, 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. As a result, the patentee may be put in a worse position than before the suit" (Choi, 1998). Finally, note that an entrant is rarely a pure imitator but she can still be condemned (or may be not) under the doctrine of equivalents. "This occurs when one is employing essentially the same technology, in essentially the same way, to achieve essentially the same result. Such infringement can exist, therefore, where there is no satisfaction of every recital of a claim" (Silverman 1992).

[9]This is a useful shortcut for modelling risk averse behavior. When the risk of the random variable $\tilde{\varepsilon}$ is small and the utility function of the agent $U(\cdot)$ is sufficiently smooth, the compensatory risk premium that should be offered to a risk averse individual for undertaking a fair gamble is equal to the insurance risk premium this individual wants to be paid to avoid the gamble. It is determined by $(-U''(W)/U'(W)).var(\tilde{\epsilon})/2$, where $(-U''/U') = \beta$ is the Arrow-Pratt measure of absolute aversion and W is the average payoff (Arrow 1971).

[10]See the Polaroïd vs. Kodak case (Warshofsky (1994), page 69): if the patentholder is almost sure to receive very high compensations F_t^h from a court, a trial can be a good *ex post* solution, better than trying to negotiate with a powerful infringer.

and the number and duration of the negotiation rounds. Let F_s^h denote this cost. After this cost is paid by the patentholder, both players begin a bargaining process in order to determine the amount of the license fee L. We assume that the outcome of this process is given by the Nash bargaining solution[11]. Consequently, we must begin by assessing the alternative utility for both players, that is how much they are sure to earn if the negotiation fails. Since the initiative is taken by the patentholder, the reservation values to take into account are the couple of gains corresponding to his highest alternative payoff.

Assume first that $\pi_d^h > \tilde{\pi}_d^h + F_t^h - \beta\sigma^2$. Hence the reservation values in the negotiation round will be the respective profits corresponding to outcome (R), π_d^h for the incumbent and π_d^i for the entrant. Since we are in a negotiation without any risk of trial in case of failure, if L denotes the amount of the fee for the use of the patent, the gross profits are respectively $\pi_d^h + L$ for the incumbent and $\pi_d^i - L$ for the entrant. Hence the net profit from bargaining is equal to L for the patentholder and $-L$ for the imitator. In other words, there is nothing to share so that the bargaining process is not a profitable alternative to the renunciation solution. Note that we obtain this outcome under the implicit assumption that both parties cannot take advantage of the negotiation to collude and maximize joint profits, for example because of a very strict antitrust policy.

Suppose on the contrary that $\pi_d^h < \tilde{\pi}_d^h + F_t^h - \beta\sigma^2$. Now, the incumbent prefers to sue the infringer rather than to accept her entry without any litigation. The term on the right-hand side of the above inequality is the reservation value to take into account by the patentholder in the bargain process and, consequently, the reservation value of the infringer is $\tilde{\pi}_d^i - F_t^i$. Hence, the judicial procedure stands for the "backup solution" for settlement.[12] It results that the licence

[11] Aoki and Hu (1999a, 1999b) use also the Nash bargaining game framework in order to analyze litigation and settlement behavior in case of patent infringement. They use this framework in order to compare the American and English rules of cost allocation.

[12] Marshall et alii (1994) note that "the settlement process provides a legal mechanism for the exchange of side-payments, while the possibility of a court decision provides the plaintiff with a credible threat against the defendant so as to avert cheating" p. 211. Even without the potential advantages of collusion, settlement is usually viewed as a better solution than trial. Among numerous examples, one can quote Michael Green (Lucent president of intellectual property): "After numerous attempts to negotiate with Cisco, we were left with no other recourse but to file suit" or an analyst at Lehman Brothers: "These things usually get settled out of court". (From CNN, June 19, 1998: "Lucent Technologis Inc. said it has filed a patent infringement suit in a federal court against Cisco Systems Inc".).

fee will be calculated as the solution of

$$\max_L (\pi_d^h + L - \tilde{\pi}_d^h - F_t^h + \beta\sigma^2)^\rho (\pi_d^i - L - \tilde{\pi}_d^i + F_t^i)^{1-\rho}$$

where ρ is a number between 0 and 1 that measures the relative negotiation power of the patentholder. It is possible that ρ be positively correlated with the compensation F_t^h received from a judicial procedure. But the qualities necessary to win in a negotiation round are probably less technical than the qualities allowing to convince a judge. For this reason, we prefer not to specify any *a priori* relation between the two concepts. The licence fee obtained from the negotiation round is therefore[13]

$$L^* = \rho[\pi_d^i - \tilde{\pi}_d^i + F_t^i] + (1-\rho)[\tilde{\pi}_d^h + F_t^h - \pi_d^h - \beta\sigma^2] \tag{1}$$

and consequently, the gross profits of the players in the settlement solution are respectively

$$\Pi^h = \pi_d^h + L^* = \rho[\pi_d^h + \pi_d^i - \tilde{\pi}_d^i + F_t^i] + (1-\rho)[\tilde{\pi}_d^h + F_t^h - \beta\sigma^2] \tag{2}$$

$$\Pi^i = \pi_d^i - L^* = (1-\rho)[\pi_d^i + \pi_d^h - \tilde{\pi}_d^h - F_t^h + \beta\sigma^2] + \rho[\tilde{\pi}_d^i - F_t^i] \tag{3}$$

The profit of the patentholder (resp. infringer) is obviously increasing with his power of negotiation ρ (respectively $1-\rho$). The risk aversion of the patentholder limits his conditions in the negotiation because, as he dislikes to go to court, he is ready to accept a reduced licence fee. Concerning the infringer, we see she will be more inclined to negotiate when the fine F_t^i is higher and when the damages F_t^h are higher. As compared with the lawsuit outcome, bilateral negotiation allows both parties to save procedure expenses. For the entrant, an extra advantage of the settlement procedure is to extinguish claims for prior infringement.

When he can identify an entrant, the best decision of the patentholder depends on the relative values of the three gross profits[14] π_d^h, $\tilde{\pi}_d^h + F_t^h - \beta\sigma^2$ and $\Pi^h - F_s^h$.

The conclusion is that the decision of the patent owner at the final stage of the game will be

(R) to accommodate entry if π_d^h is the largest value ("renunciation solution"),

(S) to propose a settlement if $\Pi^h - F_s^h$ is the largest value ("settlement solution"),

[13]The transfer from the infringer to the patentholder (licence fee) is increasing with the legal cost charged to the infringer and decreasing with the loss associated to the trial for the patentholder. This is consistent with the result of Aoki and Hu (1999a).

[14]To obtain the net final profit, it remains to substract the monitoring expenditure x.

(T) to sue the infringer if $\tilde{\pi}_d^h + F_t^h - \beta\sigma^2$ is the largest value ("lawsuit solution").

The discussion on the likelihood of each solution according to the value of parameters is relegated to section 4.

We can now discuss the main differences between our model and Meurer's (1989):

a) in our model, the potential plaintiff is the patent owner because of proved patent infringement by the competitor while, in Meurer, the plaintiff is the competitor because of the uncertain validity of the patent;

b) in Meurer, the competitor is already in the market while here entry is a decision variable;

c) in our model, to settle means to launch on a Nash bargaining round; in Meurer, the patentee makes a take-it-or-leave-it settlement offer;

d) when the firms succeed in signing the license contract, Meurer considers that they will try to collude in order to extract the monopoly profit from the market. If the government policy is permissive, they do obtain the joint maximum profit. Under a very restrictive antitrust policy, they cannot gain more than their duopoly profits before negotiating the license fee. In this paper, we have adopted the latter hypothesis;

e) unlike in our model, in Meurer the weakness of the patent is explicitly modelled by a probability of invalidity. Actually, many innovations can be "legally imitated" so that the validity of a patent is never totally certain. It results that imitation is not exceptional[15].

For each of the three final outcomes, which are supposed to be known by both players[16], we now study the simultaneous game where the patentholder chooses the level of his monitoring effort and the imitator decides whether to enter, without knowing the decision of the patentholder. Later we will consider the game where the entrant knows the monitoring effort of the patentholder before taking the decision of entry and symmetrically the game where the patentholder launches on an identification campaign upon observing a decrease in his profits.

[15] "Gillette spent ten years and $ 1 billion developing its new Mach 3 razor; it took a British supermarket only a year or so to produce a reasonable imitation" The Economist, December 4th 1999, p. 73.

[16] This is a drastic hypothesis. It would be obviously more realistic to suppose for instance that bargaining positions are private information. Several papers analyze how asymmetric information can explain failure to settlement. See for instance Hay (1995). Likewise, in Meurer (1989), the incumbent has a private information on the validity of his patent.

3 Simultaneous decisions

The imitator decides whether to enter without observing the incumbent's monitoring effort and the patentholder decides how much to spend in market watching without knowing whether the challenger is in or out. In this framework, the equilibrium concept to use is the Nash equilibrium. A strategy of player h is $x \in [0, \bar{x}]$ and a strategy of player i is $e = \{0, 1\}$. Denote by $x(e)$ the best response function of h and by $e(x)$ the best response function of i. A Nash equilibrium is a pair of strategies (x^n, e^n) such that

$$x(e^n) = x^n \quad \text{and} \quad e(x^n) = e^n.$$

First, note that whatever the final stage of the post-entry game (renunciation, lawsuit or settlement), the payoffs when the imitator decides to stay out are the pair $(\pi_m^h - x, 0)$ since we have normalized the no-entry benefits of the challenger to 0 and the patentholder remains a monopoly after spending x. Consequently, we can directly deduce that $x(0) = 0$: without entry, the best choice of the patentholder is to spend nothing.

We now consider the equilibrium corresponding to the three alternative final outcomes that follow entry.

Renunciation Solution

When the incumbent is ready to accommodate entry, the payoff of the entrant is π_d^i, to be compared with 0 if she remains outside. We deduce that $\forall x, e(x) = 1$; that is entry is a dominant strategy. When entry occurs, the payoff of the patentholder is simply $\pi_d^h - x$ which is obviously maximized at $x = 0$. Then $x(1) = 0$ and since we already know that $x(0) = 0$, we can deduce that zero monitoring expenditure is a dominant strategy. Consequently, we can assert the following:

Proposition 1 *In the simultaneous game, when the post entry solution is to accept infringement, there exists an equilibrium in dominant strategies where the patentholder does not spend anything and the imitator enters*[17]*:*

$$x^n = \underline{0} \quad , \quad e^n = \underline{1}.$$

This outcome is the equilibrium in all the markets where the patentholder considers it is worthless to deter entry. It can be either because a trial offers very little chance of winning

[17] Underlined symbols denote a dominant strategy.

any positive net compensation (China and Japan are well known for their numerous patent infringers and counterfeiters encouraged by the free-and-easy attitude of the authorities as regards intellectual property) or because the patent protects a weak innovation for which any license agreement would cost more than the expected royalties.[18]

Lawsuit Solution

We analyze now the "trial game". That is the case where a candidate to entry is sure to be sued if the incumbent can identify her. When there is entry, the net profit of the entrant is

$$G_t^i(x) = p(x)[\tilde{\pi}_d^i - F_t^i] + (1 - p(x))\pi_d^i \tag{4}$$

since she will be sued with probability $p(x)$ and she will remain unpunished with probability $1 - p(x)$. This profit is to be compared with 0 obtained when staying outside. Assume there exists a value $\tilde{x}_t$ such that $G_t^i(\tilde{x}_t) = 0$. Since $\dfrac{dG_t^i(x)}{dx} = p'(x)[\tilde{\pi}_d^i - F_t^i - \pi_d^i] < 0$, as long as $x < \tilde{x}_t$ the risk to be identified and sued is low so that entry is profitable. By contrast, no entry is the best choice for $x > \tilde{x}_t$. We conclude that the best response function of the entrant is

$$e(x) = \begin{cases} 0 & \text{if } \; x \geq \tilde{x}_t \\ 1 & \text{otherwise} \end{cases}$$

Note that if the penalty F_t^i is very high, $G_t^i(0) < 0$ which means that entry is not profitable even with no monitoring since $p(0) > 0$ makes it possible to be identified and prosecuted. If, on the contrary, $\tilde{\pi}_d^i - F_t^i$ is positive, we obtain $G_t^i(\bar{x}) > 0$ which means that entry is profitable even when the infringer is sure to be fined (recall that $p(\bar{x}) = 1$).

Concerning the patentholder, his profits are

$$G_t^h(x) = p(x)[\tilde{\pi}_d^h + F_t^h - \beta\sigma^2] + [1 - p(x)]\pi_d^h - x. \tag{5}$$

If $\dfrac{dG_t^h(0)}{dx} > 0$ and $\dfrac{dG_t^h(\bar{x})}{dx} < 0$, since $p''(x) < 0$ there exists a value of x, x_t^*, strictly positive and less than $\bar{x}$ such that $\dfrac{dG_t^h(x_t^*)}{dx} = 0$. If $G(x_t^*) > 0$, $x_t^* > 0$ is the best monitoring decision. If

[18] "However esoteric they sound, most consumer-goods technologies are unlikely to fend off imitators for long (...). Gillette's patent on a new toothbrush may specify with utmost precision how bristles are laid out; but there are lots of different "technologies" that can clean teeth just as well (...). Only 10% of the 55,000 brand new products that were launched globally last year are really innovative". The Economist, october 30th 1999, p. 85.

$\dfrac{dG_t(0)}{dx} < 0$, any spending in monitoring decreases profits so that $x_t^* = 0$ and if $\dfrac{dG^h(\bar{x})}{dx} > 0$, the best choice is $x_t^* = \bar{x}$, provided that $G(\bar{x}) > 0$. This means that the best response to entry is[19]

$$x(1) = x_t^* \in [0, \bar{x}] \text{ and we know that } x(0) = 0.$$

It results that the complete setting of the Nash equilibrium needs a comparison of $\tilde{x}_t$ (the threshold of monitoring expenditures that deters entry) and x_t^* (the patentholder's best choice when there is entry).

- If $G_t^i(\bar{x}) \geq 0$, entry is a dominant strategy and the patentholder spends x_t^* which can be a value between 0 and $\bar{x}$, as well as 0 or $\bar{x}$ if this is the best way for him to maximize his expected reward from trial.
- Conversely, if $G_t^i(0) \leq 0$, entry would be a bad decision for any level of the monitoring effort. Facing the no-entry dominant strategy, the property right owner decides to spend 0.
- The problem is more complicated when $G_t^i(0) > 0 > G_t^i(\bar{x})$. Suppose first that $x_t^* < \tilde{x}_t$. It results that $G_t^i(x_t^*) > 0$ so that we obtain an equilibrium with entry despite the monitoring effort of the incumbent. In other words, from the best response functions

$$x(e) = \begin{cases} 0 & \text{if} \quad e = 0 \\ x_t^* & \text{otherwise} \end{cases} \qquad \text{and} \qquad e(x) = \begin{cases} 0 & \text{if} \quad x \geq \tilde{x}_t \\ 1 & \text{otherwise} \end{cases}$$

  we conclude that the Nash equilibrium is $x^n = x_t^*$, and $e^n = 1$.
  Consider on the contrary the case where $x_t^* > \tilde{x}_t$. Since $G_t^i(x_t^*) < G_t^i(\tilde{x}_t) = 0$, the best response of the challenger to the effort x_t^* is to stay out. But when the challenger is out, $x_t = 0$ is the best choice of the incumbent. And since we are in the case where $G_t^i(0) > 0$, no monitoring commands entry which, in turn, triggers a positive monitoring effort x_t^*. Consequently it appears that there is no Nash equilibrium in pure strategies. But we can

[19]Note that at x_t^* the second order condition $d^2G_t^h/dx^2 < 0$ is satisfied since, in the"trial zone", it is true that $\tilde{\pi}_d^h + F_t^h - \beta\sigma^2 > \pi_d^h$.

determine an equilibrium in mixed strategies where the infringer enters with probability[20]

$$q_t^i = \frac{x_t^*}{G_t^h(x_t^*) + x_t^* - G_t^h(0)}, \tag{6}$$

the patentholder decides a zero level of enquiry with probability

$$q_t^h = \frac{G_t^i(x_t^*)}{G_t^i(x_t^*) - G_t^i(0)} \tag{7}$$

and he spends x_t^* with probability $1 - q_t^h$.

These results are summarized in Proposition 2.

Proposition 2 *In the simultaneous game, when the post entry solution is to sue the infringer at law,*

(a) if $G_t^i(\bar{x}) \geq 0$, there exists a Nash equilibrium in pure strategies $e^n = \underline{1}$, $x^n = x_t^*$,

(b) if $G_t^i(0) \leq 0$, there exists a Nash equilibrium in pure strategies $e^n = \underline{0}$, $x^n = 0$,

(c) if $G_t^i(0) > 0 > G_t^i(\bar{x})$, either $x_t^* \leq \tilde{x}_t$ and there exists a Nash equilibrium in pure strategies $x^n = x_t^*$, $e^n = 1$, or $x_t^* > \tilde{x}_t$ and there exists a Nash equilibrium in mixed strategies where the infringer enters with probability q_t^i and the patentholder does not monitor his market with probability q_t^h or spends x_t^* with probability $(1 - q_t^h)$.

Case (b) is well illustrated by the pharmaceutical patents. In this industry, patents protect innovations that have been very costly to obtain and that promise high prize. Because going through clinical trials and administrative approval is long and verifiable, pure imitation is easy to detect and to prove. It results that patent challenges on drugs are rare.

[20] This is an equilibrium in the following sense: if the patentholder does not monitor with probability q_t^h and spends x_t^* with probability $1 - q_t^h$, then the potential imitator is indifferent between entry and no entry. Reciprocally, if the challenger decides to enter with probability q_t^i and to stay out with probability $1 - q_t^i$, the incumbent is indifferent between spending x_t^* or 0 in market watching.

Settlement Solution

In the "settlement game", the net profits are respectively

$$G_s^h(x) = p(x)(\Pi^h - F_s^h) + (1 - p(x))\pi_d^h - x \tag{8}$$

for the patentholder, and

$$G_s^i(x) = p(x)\Pi^i + (1 - p(x))\pi_d^i \tag{9}$$

for the entrant, where Π^h and Π^i are defined in (2) and (3) respectively.

As the problem is similar to the preceding one, using evident notations we can directly assert the following:

Proposition 3 *In the simultaneous game, when the post entry solution is to come to arrangement with the infringer,*

(a) if $G_s^i(\bar{x}) \geq 0$ *there exists a Nash equilibrium in pure strategies* $e^n = \underline{1}$, $x^n = x_s^*$,

(b) if $G_s^i(0) \leq 0$ *there exists a Nash equilibrium in pure strategies* $e^n = \underline{0}$, $x^n = 0$,

(c) if $G_s^i(0) > 0 > G_s^i(\bar{x})$*, either* $x_s^* \leq \tilde{x}_s$ *and there exists a Nash equilibrium in pure strategies* $x^n = x_s^*$, $e^n = 1$ *or* $x_s^* > \tilde{x}_s$ *and there exists a Nash equilibrium in mixed strategies where the entrant randomizes between entry (probability* q_s^i*) and no entry* $(1 - q_s^i)$ *while the patentholder randomizes between spending zero (probability* q_s^h*) and spending* x_s^* *(probability* $1 - q_s^h$*) to monitor his market*[21].

4 Parametrization of the equilibria

The alternative equilibria of the former section can be charted with respect to several set of parameters. We have chosen a presentation in terms of the following pair of parameters: the fine charged to the infringer in case of condemnation F_t^i and the cost to launch on a settlement round F_s^h.

[21] The probabilities q_s^i and q_s^h are defined like in (6) and (7) with the functions $G_t^i(\cdot)$ and $G_t^h(\cdot)$ replaced by $G_s^i(\cdot)$ and $G_s^h(\cdot)$ respectively.

4.1 Rules for penalty and settlement costs

In case of successful trial, the judge determines the level of damages allocated to the patentholder (F_t^h) as well as the penalty that the imitator has to pay (F_t^i). We assume that damages are a fraction of the penalty,

$$F_t^h = \alpha F_t^i \quad \text{where} \quad 0 < \alpha < 1. \tag{10}$$

Indeed, the patentholder does not receive the whole penalty ($F_t^h < F_t^i$), because of the procedure fees and lawyers' retainers[22].

Concerning the amount of the penalty, we can think of different setting rules. For instance, we can imagine that the indemnity must be exactly equal to the loss associated with a duopoly situation as compared with a monopoly $(\pi_m^h - \tilde{\pi}_d^h)$[23]. In this case, the penalty for the imitator becomes $F_t^i = \dfrac{\pi_m^h - \tilde{\pi}_d^h}{\alpha}$. If the infringer was willful, the court can increase damages up to three times the actual ones. It can also occur that the losing party is condemned to pay the attorney's fees of the other side[24].

To remain as general as possible, we keep the penalty as a variable parameter which obviously includes the former particular cases. Depending on the values of F_t^i and F_s^h we first determine whether the patentholder prefers a settlement to a trial or to renunciate. Second, we examine the split of the different types of equilibria. Finally, we analyze how they react to change in parameters.

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[22]In their model, Aoki and Hu (1999b) consider that the damage reward obtained by the patentholder in case of trial is what the infringer pays if he loses the trial ($\alpha = 1$). However it seems reasonable to assume that the patentholder will always get less than what the infringer eventually pays, because of the lawyer's expenditures.

[23]The Polaroïd vs. Kodak case is a good example: "Kodak was to pay Polaroïd $ 454 million in compensation for the 10 years its instant products were on the market. An additional $ 455 million was added on as interest" (Warshofsky, 1994, p.87).

[24]It is the common rule in the British system; in the USA each party in patent litigation pays its own legal fees except in case of willful infringement (Meurer, 1989; Aoki and Hu, 1999a, 1999b). For example "Polaroid's request for treble damages for willful infringements by Kodak were denied by the judge" (Warshofsky, 1994, p.87). By contrast, on July 1997, Biotek Solutions Inc. was ordered to pay punitive damages for willfully infringing Biogenex's patent on the "Antigen Retrieval" procedure for treating tissue specimens. The total to be paid by Biotek was $ 404,150 for compensatory damages, $ 303,112 for punitive damages, $ 102,460 for interest on the compensatory damages since the time of infringement and about $ 40,000 for certain litigation costs.

4.2 Choice between settlement, trial or inaction

From section 2, we know how the patent owner decides on the final step of the game between accepting entry, suing the infringer or proposing a settlement. Consequently, we can determine the pairs (F_s^h, F_t^i) such that the incumbent is indifferent between two of these decisions. Indeed, in order to decide whether to fight or not, the patentholder has to compare the net benefits of a trial and the net benefits of a settlement with π_d^h that can be obtained by accepting entry.

The patentholder is indifferent between the renunciation solution and the lawsuit solution if

$$\pi_d^h = \tilde{\pi}_d^h + F_t^h - \beta\sigma^2$$

which gives, using relation (10),

$$F_t^i = \frac{\pi_d^h - \tilde{\pi}_d^h + \beta\sigma^2}{\alpha}. \tag{11}$$

This function is the vertical frontier between areas [R] and [T] in figure 1.

The patentholder is indifferent between the renunciation solution and the settlement solution if

$$\pi_d^h = \Pi^h - F_s^h.$$

Using (2) and (10), we obtain

$$F_s^h = [\alpha + (1-\alpha)\rho]F_t^i + \rho(\pi_d^i - \tilde{\pi}_d^i) + (1-\rho)(\tilde{\pi}_d^h - \pi_d^h - \beta\sigma^2), \tag{12}$$

which is the increasing frontier between areas [R] and [S] in figure 1.

Finally, indifference between settlement and trial is defined by

$$\Pi^h - F_s^h = \tilde{\pi}_d^h + F_t^h - \beta\sigma^2.$$

Using (2) and (10) we obtain

$$F_s^h = \rho(1-\alpha)F_t^i + \rho(\pi_d^h - \tilde{\pi}_d^h + \pi_d^i - \tilde{\pi}_d^i + \beta\sigma^2), \tag{13}$$

that is an increasing function separating the areas [S] and [T] in figure 1.

One can easily check that (11), (12) and (13) converge toward a pivot point around which the three possible outcomes of the game are located.

insert Figure 1

For given values of the other parameters, if the negotiation cost F_s^h is small enough, the patentholder obviously prefers to negotiate instead of going to court. Furthermore, for small values of the penalty F_t^i, the patentholder even prefers to renunciate, and let the imitator be in the market. This is because the decision of negotiation internalizes the costs associated with a trial. When the patentholder has to decide whether to negotiate or not, he also takes into account the penalty paid by the imitator in case of trial. As long as F_s^h is not too high, for large values of damages, the incumbent prefers to negotiate with the infringer rather than going to court. Here again it is because the cost associated with a trial has to be taken into account in the negotiation decision.

For larger values of the negotiation cost (that is in the upper part of figure 1) the patentholder may have to choose between abandoning, pursuing the imitator or negotiating. Indeed, there exists a cutoff value for which a trial has to be considered because it becomes costly to negotiate. For small values of the penalty, the patentholder prefers to accommodate entry. For intermediate values of the penalty the patentholder is better off by pursuing the imitator. It is costly to negotiate and the penalty paid by the imitator will reimburse a part of the cost associated to a trial. But, for values of the penalty large enough, the patentholder prefers a settlement to a trial, since the cost associated with a trial can be saved and the incumbent can be compensated for commercial losses through license fees.

4.3 Different types of equilibria

We now analyze the equilibria within each of the three areas of figure 1 described in the former paragraph, using propositions 1, 2 and 3.

(i) When the final outcome is “no reaction by the patent owner”, we have the simplest type of equilibrium: equilibrium in dominant strategies where the incumbent spends nothing to monitor his market and the imitator enters. This pair of decisions need no strategic reasoning by players: it is only based on the very low observed or expected value of the fines in case of infringement F_t^i. The obvious question is why the innovator has paid for a patent if he is not ready to defend it against violators. But this question is to be asked before our story begins. We just observe as a stylized fact that many innovators apply for a patent without exploring the future costs of legal protection[25].

[25] However, some recent econometric study show that innovators worry about litigation cost before patenting. See Lerner (1995).

(ii) In zones $[S]$ and $[T]$ we have a larger spectrum of equilibria. Consider first the trial zone, that is the upper part on the right of figure 1. By proposition 2, we have to distinguish three equilibria.

(a) When $G_t^i(\bar{x}) \geq 0$, that is by (4) when $F_t^i \leq \tilde{\pi}_d^i$, entry is a dominant strategy for the imitator. The incumbent does not have a dominant strategy but, knowing the challenger's decision, his best choice is to spend x_t^* in monitoring.

(b) In the same way, when $G_t^i(0) \leq 0$, i.e. when $F_t^i \geq \tilde{\pi}_d^i + \frac{1-p(0)}{p(0)}\pi_d^i$, the expected profits of the entrant are negative whatever the monitoring effort of the patentee. Consequently, the challenger's decision to stay out is dominant and the incumbent can infer that his best choice is to spend nothing.

Within region $[T]$, these two zones are delineated by vertical frontiers in figure 1, since the cut-off values of F_t^i do not depend on F_s^h: the region depited in (a) is the left part of $[T]$ while the one depicted in (b) is the right part of $[T]$.

(c) We examine now part (c) of proposition 2. Assuming that x_t^* is an internal solution, it is defined by

$$p'(x_t^*)[\tilde{\pi}_d^h + \alpha F_t^i - \beta\sigma^2 - \pi_d^h] - 1 = 0,$$

where the expression into brackets is positive as long as we are in the lawsuit zone. Consequently, it is easy to check that $\frac{dx_t^*}{dF_t^i} > 0$: the higher the fine for infringement, the greater the optimal monitoring expenses of the patentholder.

By contrast, we know that the monitoring expenditures that dissuade entry are $\tilde{x}_t$ defined by

$$p(\tilde{x}_t)[\tilde{\pi}_d^i - F_t^i - \pi_d^i] + \pi_d^i = 0,$$

where the expression into brackets is negative. It results that $\frac{d\tilde{x}_t}{dF_t^i} < 0$: the expenditures that deter entry are lower when the fine is high.

Consequently, we can say that $x_t^* < \tilde{x}_t$ (respectively $x_t^* > \tilde{x}_t$) for low (resp. high) values of F_t^i. Note also that the above expressions do not depend on F_s^h. Then, using proposition 2.(c), we can conclude that for $\tilde{\pi}_d^i \leq F_t^i \leq \tilde{\pi}_d^i + \frac{1-p(0)}{p(0)}\pi_d^i$, that is in the central part of $[T]$, there exists a vertical frontier between

- on the left, a Nash equilibrium in pure strategies $e^n = 1, x^n = x_t^*$ and,
- on the right, a Nash equilibrium in mixed strategies.

(iii) In the lower part of figure 1, players know that the final outcome will be to settle. Using proposition 3, if $G_s^i(\bar{x}) \geq 0$, that is if,

$$F_t^i \leq \dot{F} \stackrel{def}{=} \frac{\rho\tilde{\pi}_d^i + (1-\rho)(\pi_d^i + \pi_d^h - \tilde{\pi}_d^h + \beta\sigma^2)}{\rho + (1-\rho)\alpha},$$

entry is a dominant strategy, which provokes expenditures $x^n = x_s^*$ by the patentee. It is easy to check that $\dot{F} \geq \tilde{\pi}_d^i$ and the equality holds only when the incumbent has the whole bargaining power ($\rho = 1$). It means that entry is more likely to happen than in the lawsuit zone, as long as the imitator is able to resist to the incumbent $(1 - \rho > 0)$.

By proposition 3(b), no entry is a dominant strategy, and consequently $x^n = 0$ is the incumbent's best choice, when $G_s^i(0) \leq 0$, that is when

$$F_t^i \geq \ddot{F} \stackrel{def}{=} \frac{\rho\tilde{\pi}_d^i + (1-\rho)(\pi_d^i + \pi_d^h - \tilde{\pi}_d^h + \beta\sigma^2) + \dfrac{1-p(0)}{p(0)}\pi_d^i}{\rho + (1-\rho)\alpha}.$$

Since $\ddot{F} \geq \tilde{\pi}_d^i + \dfrac{1-p(0)}{p(0)}\pi_d^i$ and the equality holds only for $\rho = 1$, we can also infer that no entry is dominant in the settlement zone less often than in the trial zone as long as the imitator has some negotiation power.

It remains to examine what occurs for $\dot{F} < F_t^i < \ddot{F}$, that is when Proposition 3(c) holds. Using the same argument as in paragraph (ii-c) above, it is easy to prove that $\dfrac{dx_s^*}{dF_t^i} > 0 > \dfrac{d\tilde{x}_s}{dF_t^i}$ so that we will have a Nash equilibrium in pure strategies ($e^n = 1$, $x^n = x_s^*$) for low values of F_t^i and a Nash equilibrium in mixed strategies for higher values of F_t^i. Nevertheless, the situation is not exactly the same as in the trial zone. Now, x_s^* is also a function of F_s^h $\left(\dfrac{dx_s^*}{dF_s^h} < 0\right)$, while $\tilde{x}_s$ is not affected by changes in F_s^h. Consequently, the set of pairs (F_t^i, F_s^h) such that $x_s^* = \tilde{x}_s$ gives an increasing function.

When F_s^h is either very high or very low, an increase in F_t^i has the normal effect to decrease the likelihood of entry. It is interesting to note that this can be no longer true for intermediary values of F_s^h. Consider for example an increase of the fine from A to B, then from B to C in figure 1. At A the probability of entry is 1, it is less than 1 in B, and it increases back to 1 at point C. We see that a higher penalty increases (locally) the likelihood of entry: the reason is that while at point B the imitator hesitates to enter (plays randomly) because she is not sure to be sued, at point C negotiation allows to avoid judicial expenditures for both as well as the risk aversion of the patentee.

4.4 Variations in parameters

We now discuss how the zones identified in the former section change when there is a variation of some parameters. We consider changes in the fraction of the penalty that the patentholder will get in order to indemnify him, changes in the bargaining power of the patentholder and changes in the risk premium parameters.

When α, the fraction of the penalty that the patentholder gets from the imitator increases, using (11),(12) and (13) we see that the trial area spreads out both because the frontier between (R) and (T) moves left and the frontier between (T) and (S) becomes flatter. Actually, the imitator's gain in case of settlement becomes smaller because the patentholder has a higher reservation utility due to the trial threat, and consequently he can impose a higher licence fee. On the contrary, if α decreases to 0, the trial zone shrinks and the choice is limited to renunciate or to settle. Within each zone, the likelihood of each type of equilibrium is also affected. For example, when α increases, $\dot{F}$ and $\ddot{F}$ moves leftward, hereby decreasing the probability of entry in the settlement zone. In the trial zone, as the eastern frontier of the equilibrium $(e^n = \underline{1}, x^n = x_t^*)$ is fixed at $\tilde{\pi}_d^i$, a decrease in α means a progressive vanishing of this zone, followed by the central one, and so on.

When the bargaining power of the patentholder ρ increases, the settlement area increases (see (12) and (13)). Indeed, with a higher negotiation power, the patentee can impose a higher licence fee. Then he prefers to negotiate instead of going to court. Furthermore, for small values of the settlement cost, the patentholder always prefers to negotiate. There is no trade-off between negotiating and abandoning. If the bargaining power is too large, even for very small values of the negotiation cost, the patentholder prefers to abandon when the penalty is too small. In this case the settlement area shrinks.

When the patentholder becomes more risk averse or when the risk of the trial outcome increases, then the whole graph moves towards the right. It means that the renunciation area as well as the settlement area become larger. Obviously, the trial area is reduced: indeed the more risk averse the patentholder is, the less often he wants to go to court. The trial solution will be considered only for high values of the fee paid by the infringer and of the cost associated to a settlement.

5 The sequential games

Instead of supposing that the entry decision and the monitoring expenditures are chosen without knowing the decision of the other agent, we can consider situations in which the agents play sequentially, the second player knowing the decision of the first one. Two sequential games can be analyzed. In the first one, the entrant observes the value of x, and consequently knows the probability to be identified before entering. In the second game, by contrast, the patentholder decides how much to spend in monitoring after he has detected an entry. How do these alternative scenarios change the results of the preceding models?

5.1 The patentholder plays first

The pertinent notion of equilibrium is now the perfect equilibrium. The patentholder chooses $x \in [0, \bar{x}]$ and, observing x, the entrant takes a decision conditional to x: her best choice is a function $e(\cdot)$ mapping the segment $[0, \bar{x}]$ into the dichotomic set $\{0, 1\}$.

As compared with the simultaneous game, the main difference is that $\tilde{x}_t$ (in the trial game) or $\tilde{x}_s$ (in the settlement game) is now an essential strategy for the patentholder. Indeed, in the simultaneous case for $G_j^i(0) > 0 > G_j^i(\bar{x})$ (where j stands for s or t) entry could be deterred only as a lucky by-product of the decision to maximize the incumbent's expected profits (while randomization selects either 0 or $x_j^* > \tilde{x}_j$ by chance, the challenger draws the decision to stay out of the market). By contrast, now the patentholder can set his expenditures voluntarily at the value $\tilde{x}_j$ with the expected consequence to deter entry.

Then knowing the reaction function

$$e(x) = \begin{cases} 0 & \text{if} \quad x \geq \tilde{x}_j \\ 1 & \text{otherwise} \end{cases}$$

the incumbent chooses between x_j^* that maximizes the post entry profit $G_j^h(x)$ and $\tilde{x}_j$ that gives him $\pi_m^h - \tilde{x}_j$ since entry is deterred.

Suppose first that $\tilde{x}_j < x_j^*$. Consequently, $\pi_m^h - \tilde{x}_j > \pi_m^h - x_j^* > p(x_j^*)[\tilde{\pi}_d^h + F_t^h - \beta\sigma^2] + (1 - p(x_j^*))\pi_d^h - x_j^*$. It results that the sequential or Nash perfect equilibrium is

$$x^{np} = \tilde{x}_j \quad , \quad e^{np}(x) = \begin{cases} 0 & \text{if} \quad x \geq \tilde{x}_j \\ 1 & \text{otherwise} \end{cases}$$

and on the equilibrium path entry does not occur.

If, on the contrary, $\tilde{x}_j > x_j^*$, we can observe accommodated entry (when $G_j^h(x_j^*) > \pi_m^h - \tilde{x}_j$) or, otherwise deterred entry as above. The fact that the patentholder accommodates entry does not mean that he will not react since with probability $p(x_j^*)$ the infringer will be prosecuted when $j = t$ or will produce under license and pay royalties when $j = s$.

When $G_j^i(0) < 0$ or when $G_j^i(\bar{x}) > 0$, the game remains intrinsically identical to the simultaneous one since the entrant has a dominant strategy, no entry in the first case, entry in the second case, whatever the observed value of x. Consequently, we can state the following.

Proposition 4 *When monitoring expenses are observed by the entrant before she takes her decision, the patentholder is more likely to deter entry than in the simultaneous game.*

This signalling value of market watching can be implemented through advertising campaigns in professional newspapers or through public annoucements about the establishment of an intelligence service. Some companies are even accused of concentrating exclusively in litigation procedure: Sidney Taurel, CEO of Eli Lilly claimed that "Sherman (CEO of Apotex, the biggest pharmaceutical company in Canada) basically chooses to litigate. I consider their legal expenses a little bit like our R&D expenses" (Fortune, September 6, 1999).

5.2 The imitator plays first

What changes do this new setting provoke in the former results?

The perfect equilibrium is made of a decision $e = \{0, 1\}$ taken by the candidate to entry and a reaction function of the patentholder $x(\cdot)$, mapping the set $\{0, 1\}$ into $[0, \bar{x}]$. When there is no entry, $x(0) = arg \max_x \pi_m^h - x$ is obviously 0. When there is entry the decision of the incumbent is $x(1) = arg \max_x G_j^h(x)$ which is x_j^* or in case of corner solutions, 0 or $\bar{x}$.

It appears that the main difference with the simultaneous game framework is that now randomization is never necessary to obtain an equilibrium. Knowing the reaction function of the property right owner,

$$x(e) = \begin{cases} 0 & \text{if} \quad e = 0 \\ x_j^* & \text{otherwise} \end{cases}$$

the challenger has just to compare it with $\tilde{x}_j$. If $x_j^* < \tilde{x}_j$ she enters, and if $x_j^* > \tilde{x}_j$, she stays out of the market.

Proposition 5 *When the monitoring expenditures are decided after an entry has been detected, the challenger is more likely to stay out than in the corresponding simultaneous game.*

This result can be interpreted in the following way. In a simultaneous game as well as in the sequential game where the patentholder takes an observable decision, monitoring expenditures are actually two dimensional. On the one hand, they are dissuasive since the challenger can anticipate the inconvenient of entry, and on the other hand they are punitive since they increase the chances to extract revenues from an infringer. By contrast, when monitoring is totally decided *ex post*, it plays only one role, which is to improve the chances to compensate the patentholder. As the incumbent will decide for sure how much to spend instead of randomizing between 0 and x_j^* (when $x_j^* > \tilde{x}_j$)[26], entry is more costly.

We see that the main effect of sequentiality is to make the decisions of both players more efficient in the following sense. When playing first, the incumbent can send valuable information to the potential competitor who can avoid to be trapped in a non profitable lawsuit. When the challenger plays first, the patentholder can proportionate his monitoring effort to an efficient repression (or negotiation) instead of spending resources in order to identify maybe no one.

6 Conclusion

The patent protection is not perfect: it just grants the right to sue intruders if they have been identified. In other words, the patentholder has to monitor his protected market by his own in order to detect and identify an infringer. Once he identifies the infringer, the patentholder has to decide how to react to the infringement. He may decide to go to court, to agree upon some kind of arrangement or to let the infringer be in the market.

In this paper we investigate how intensive should be the monitoring effort and how a potential infringer takes his entry decision. First, we have considered a simultaneous game in which both the patentholder and the infringer take their monitoring and entry decision at the same time. We have shown that if the penalty paid by the infringer is high enough, and the settlement cost is not too high, the patentholder may decide to choose a settlement instead of going to court. This is due to the fact that all the costs associated with a trial have to be taken into account in the negotiation decision. Furthermore, the likelihood of entry increases with the penalty for certain values of the parameters of the model. Second we have considered two sequential games. In the first game the patentholder chooses his monitoring effort before the imitator takes his entry decision. In the second game, the imitator decides to enter before the patentholder chooses

[26]See (c) in propositions 2 and 3.

his monitoring effort; the patentholder observes whether entry occurs and then he investigates to determine the identity of the infringer. Entry occurs less often in these sequential games as compared with the simultaneous game.

Throughout the paper, we did not make any assumption about the probability of success in case of litigation for the patentholder or for the infringer. In a future development of this paper, we will assume that the patentholder has a better information concerning his patent, its weakness and strength as in Meurer (1989)'s model. Furthermore we will capture the idea of reputation in a dynamic framework as developed by Choi (1998).

References

Aoki, R. and J.L. Hu. (1999a) "Imperfect Patent Enforcement , Legal Rules and Settlement", *Working Paper.*

Aoki, R. and J.L. Hu. (1999b) "A Cooperative Game Approach to Patent Litigation, Settlement, and Allocation of Legal Costs", *Working Paper.*

Arrow K.J. (1971) "Essays in the Theory of Risk Bearing", North-Holland American Elsevier.

Choi, J.P. (1998) "Patent Litigation as an Information - Transmission Mechanism", *American Economic Review*, December, vol. 88 n°5, 1249-1263.

Cooter, R. and D. Rubinfeld (1989) "Economic Analysis of Legal Disputes and their Resolution", *Journal of Economic Literature*, 27, 1067-1097.

Crampes C. and C. Langinier (1998) "Information Disclosure in the Renewal of Patents", *Annales d'Economie et de Statistique*, 49/50, 266-288.

Gallini, N. (1991) "Patent Policy and Costly Imitation", *Rand Journal of Economics*, 23, 52-63.

Hay, B.L. (1995) "Effort, Information, Settlement, Trial", *Journal of Legal Studies*, Vol. XXIV, January, 29-62.

Lanjouw J. and J. Lerner (1997) "The Enforcement of Intellectual Property Rights: a Survey of the Empirical Literature", NBER, working paper # 6296.

Lanjouw J. and M. Schankerman (1998) "Stylized facts of Patent Litigation: Value, Scope and Ownership", WP., *London School of Economics* EI/20.

J. Lerner (1995) "Patenting in the Shadow of Competitors", *Journal of Law and Economics*, XXXVIII, p. 463-495.

Marshall, R.C., M.J. Meurer and J.F. Richard (1994) "Litigation Settlement and Collusion", *Quarterly Journal of Economics*, February, 109(1), 211-239.

Meurer, M.J. (1989) "The Settlement of Patent Litigation", *Rand Journal of Economics*, Spring, 20(1), 77-91.

Silverman, A.B. (1992) "Patent Infringement. Is it Better to Fight or Switch?", JOM, 44(5), p. 66.

Warshofsky, F. (1994) *The Patent Wars*, John Wiley and Sons, New York.

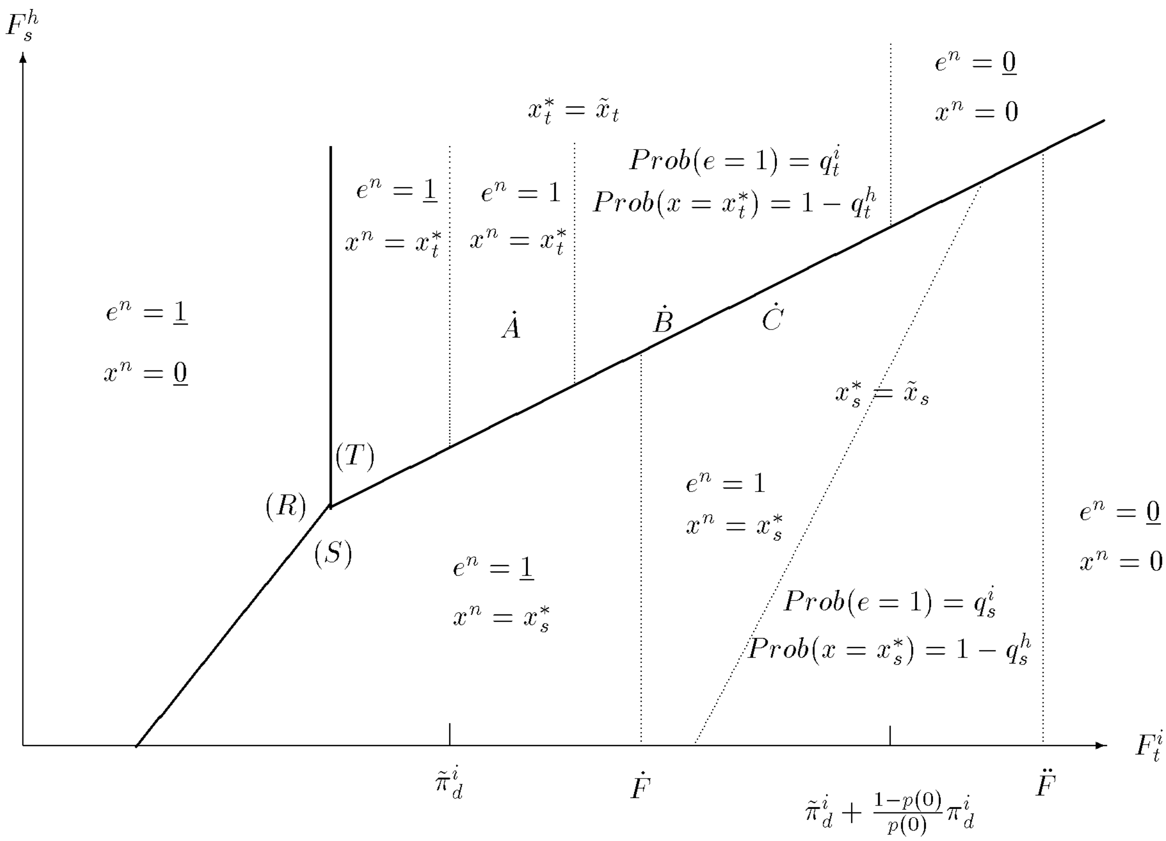

Figure 1: Different types of equilibria

(dominant strategies are underlined)