Licensing vs. Litigation: Effect of the Legal System on Incentives to Innovate

Reiko Aoki *
Department of Economics
SUNY Stony Brook

Jin-Li Hu
Dept. of Industrial Economics
Tamkang University
Taiwan.

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Abstract

With uncertain scope of patent protection and incomplete enforcement, the effective strength of patent protection is determined by the legal system. We analyze how the legal system effects the incentives of firms to innovate, taking into account possibilities of strategic licensing and litigation to deter infringement. The legal regime that induces licensing provides incentives to exert R&D effort while preserving ex-post efficiency. However the ex-ante socially optimal patent-legal system depends on the technological opportunities available to the society. We also show that change from the American to English rule of legal cost allocation does not alter our results in a fundamental way.

*Correspondences: Department of Economics, SUNY at Stony Brook, Stony Brook, NY 11794-4384, raoki@datalab2.sbs.sunysb. We are grateful to Thomas J. Prusa and Yossi Spiegel.

1 Introduction

One estimate is that the probability of the patentee winning a patent infringement suit between 1978 and 1985 was 48% (Hylton (1993)). During the 1980's, the number of patent infringement suits rose by 50% and the plaintiff was successful in about 80% of the cases (Warshofsky (1994)). This change is attributed to the establishment of the Court of Appeals for the Federal Circuit in 1982. The court was established to handle appellate review of patent infringement decisions of the lower courts and to streamline the whole patent litigation process. It also made it possible to have cases heard by judges who were familiar with intellectual property. This had the effect of property rights being upheld in cases where it would not have been before.

Judging from these numbers, the protection offered by a patent is nowhere near perfect. They also suggest that the actual strength of patent protection not only depends on the words of the patent law but also on how the law is implemented. In fact the aforementioned change in the United States was part of the pro-patent policy during the Reagan administration which did not include any change in the patent law itself. In this paper we start with the assumption that patent protection is not perfect and that the effective strength of patent protection is determined by the legal system.

We analyze the implication of the legal system supporting patents on firms' incentives to innovate, taking into account the various strategic choices made by firms because patent protection is not perfect. In our formulation, the legal system is captured by the probability of successfully defending the patent and by the legal costs. A rival is able to imitate a patentee's technology but the legal

system is unable to enforce patent protection perfectly or with certainty. In such an environment, the patentee can either license or litigate in order to appropriate returns from its patented technology. Thus the legal system determines directly the post-innovation market structure and also indirectly effects firms' incentives to innovate.

We first show that a patentee may decide to license the technology to prevent imitation. This occurs when (1) the legal costs and probability of winning make the patent owner unable to credibly threaten with an infringement suit; or (2) the patentee credibly threatens to sue, but the potential infringer's legal cost is so low that he is willing to go to court. In these cases, it is better for the patentee to share the market and collect the licensing fee than to incur the legal cost and possibly share the market. A patentee is able to credibly threaten with litigation and prevent infringement only when potential infringer's legal cost is very high. If both sides' legal costs are too low, there is infringement and litigation, which is socially wasteful.

Achieving duopoly through licensing saves on litigation and imitation costs and maximizes ex-post (innovation) welfare. Since licensing fee is a transfer from the infringer to the patentee, the patentee actually does better than duopoly profit. This provides the incentive to innovate successfully and attain the patent. Licensing fee will always depends on the imitation cost and also on the litigation costs when threat of litigation is credible. Thus R&D incentive will differ according to if litigation is a real possibility or not.

In order to maximize ex-ante welfare, ex-post efficiency and the incentive to innovate must be balanced. In determination of the socially optimal patent

regime, there is a monotonic relationship between marginal cost of innovation and strength of patent protection. Monopoly is warranted when technological opportunity is limited and thus R&D cost is high. When innovation is less costly, the optimal legal system induces licensing. The extra incentive to innovate by making litigation a credible threat is necessary when R&D cost is high (i.e., technological opportunity is limited, but not enough to make ex-post monopoly optimal). Under no circumstances were we able to show that a legal system in which litigation actually taking place is ex-ante efficient.

There are several features of the U.S. patent system which makes patent protection imperfect and uncertain. The "equivalence doctrine" implies that a patent covers not only what is exactly described in the patent registration, but also those technologies and products that are "equivalent". But exactly what constitutes "equivalent" is left to the jury to decide, leaving the exact scope of patent protection uncertain and impossible to predict *a priori*. The "first to invent" principle of allocating patent right also adds uncertainty to the validity of a patent. Until recently, the lack of opportunity for opposition [1] before a patent is registered was another source of uncertainty.

Most of the literature on optimal patent design has assumed perfect patent protection and characterized optimal breadth and length (Reinganum (1982), Judd (1985), Klemperer (1990), to name a few) or other aspects of predictable protection (Scotchmer and Green (1990)). Gallini (1992) considered optimal

[1] In most industrialized countries such as Japan and France and also the U.S. since June 1995, there is an opportunity of several month after examination and before registration in which interested parties are allowed to oppose or try to limit the coverage of a patent. In Germany, the opposition period is three month immediately following the registration of a patent.

patent length with costly imitation (like ours) but again patent protection was assumed perfect. Although we are also interested in the optimal patent system, we focus on the legal system supporting the imperfect patent.

By considering imperfect patent protection we identify a new incentive of firms to license. Previous analysis of strategic licensing have all assume that there is no uncertainty about the scope of patent protection and enforcement is perfect (Gallini (1984), Rockett (1990), Gallini and Winter (1985)[2] , Farrel and Gallini (1988), Economides (1992). We show there is licensing precisely because protection is not perfect. This is also somewhat contrary to what Katz and Shapiro (1987) assumed when they examined the effect of patent protection on R&D behavior of firms. They argued that a strong patent protection is characterized by licensing while a weak one is characterized by imitation. Our results suggest that the relationship is more complex, the legal system being one of the factors which determine the relationship.

We introduce the model and analyze the licensing-imitation-litigation decision in the next section. The equilibrium payoffs from this game are used to analyze the incentives to innovate in section 3. We also discuss the socially optimal patent legal system in the section. English and American rules of legal cost allocation are compared in section 4. We relate our work to those of other models of imperfect patent protection in section 5.

[2]The timing and the incentive to license we consider differs from the ex-ante licensing analyzed by Gallini and Winter (1985). Ex-ante licensing in their framework is on the pre-innovation technology and it can be desirable because the success of innovation is uncertain and the license serves as an insurance. We consider the licensing of a new technology, after innovation but before imitation. Licensing occurs to prevent imitation which is costly but deterministic.

2 Licensing vs. Litigation and Ex-post Efficiency

We first consider the following game between firm S, which has successfully innovated and attained a patent, and firm U, the unsuccessful firm. (See Figure 1.) Firm S offers to license the technology to firm U at a fee $F \in [0, \infty)$. Then firm U can either accept (A) or not accept (NA) the licensing offer. If it accepts, the market will be a duopoly. Firm S's payoff is $\pi_d + F$ and firm U gets $\pi^d - F$.

If firm U does not accept the offer, then it has a choice of infringing (I) on the patent at a cost of h or exiting the market (E). The payment h is the imitation cost and we assume $h < \pi_d$. Infringement is profitable if there is no challenge by the patentee. Since we are explicitly modeling the litigation process, h is the actual physical cost of imitation. It does not reflect the legal process or strength of patent protection. If firm U exits, then firm S gets the monopoly profit π_m and firm U gets nothing.

If firm U infringes, then firm S may litigate (LI) or not litigate (NL). If litigation does not take place, then the market will be a duopoly and firm S gets π_d and firm U gets $\pi_d - h$. If there is litigation, then firm S incurs litigation cost of L and firm U's cost is ℓ. The two firms have a common prior θ, the probability of firm S winning the lawsuit. If firm S wins, the market will be a monopoly and it will be a duopoly otherwise. Thus if firm S chooses litigation, then its (expected) payoff is $\theta\pi_m + (1-\theta)\pi_d - L$ and firm U's (expected) payoff is $(1-\theta)\pi_d - \ell$. We also assume the "efficiency effect" exists, that is, $\pi_m > 2\pi_d$. Thus our infringement litigation has the property that the total payoff depends on the outcome of the suit (Muerer (1989), Aoki and Hu (1995b)).

We assume that probability of winning a patent infringement suit is determined by the legal system and is exogenous to the model. The parameter θ reflects the degree of patent protection offered by the patent law itself and also through the interpretation of the law by the courts or the patent office. In particular, it is independent of the litigation costs L and ℓ.[3] The parameters L and ℓ reflect attorneys' fees relative to other costs and other transaction costs involved with going to court. It may also include such costs as loss of good will in the industry.

The game is illustrated in Figure 1. Strategy of firm S is ($F \in [0, \infty)$, LI or NL). Firm U's strategy is (A or NA, I or E). The subgame perfect Nash equilibrium of the game can be found by verifying the incentives at each stage, starting from the last node and working backwards. The equilibrium strategies and the outcomes differ according to the relative size of litigation and imitation costs, probability of winning and profits. There are four regimes (I through IV) in all.

Lemma 1 *We define the four following regimes:*

$$\begin{array}{lllll}
\text{(I)} & L > \theta(\pi_m - \pi_d). & & & \\
\text{(II)} & L \leq \theta(\pi_m - \pi_d), & \ell > (1-\theta)\pi_d - h. & & \\
\text{(III)} & L \leq \theta(\pi_m - \pi_d), & \ell \leq (1-\theta)\pi_d - h, & L + \ell \geq \theta(\pi_m - 2\pi_d) - h. \\
\text{(IV)} & L \leq \theta(\pi_m - \pi_d), & \ell \leq (1-\theta)\pi_d - h, & L + \ell < \theta(\pi_m - 2\pi_d) - h.
\end{array}$$

The equilibrium strategies for each regime are:

Regime	Firm S	Firm U
(I)	(h, NL)	(A, I)
(II)	(F', LI) *for any* $F' > \pi_d$	(NA, E)
(III)	$(\theta\pi_d + h + \ell, L)$	(A, I)
(IV)	(F', LI) *for any* $F' > \theta\pi_d + \ell + h$	(NA, I)

[3]For analysis when θ is a function of L and ℓ, see Hu (1995). It is very sensitive to the functional form of θ.

The four regimes in the (L, ℓ) space are illustrated in Figure 2. The following observation is illuminating.

Lemma 2 *When $L = \theta(\pi_m - \pi_d)$, the patent owner credibly threatens to litigate the infringer.*

Proof: If the patent owner does not threaten to litigate the infringer, the maximum license fee it can appropriate is only the physical imitation cost h and the other firm will definitely enter the market since $h \leq \pi_d$. But if the patentee threatens to litigate, the highest license fee it can extract is $\theta\pi_d + \ell + h$. So the patentee is strictly better-off by threatening to litigate when it feels indifferent between litigation or not. Therefore it is a dominant strategy for the patentee to threaten to litigate when $L = \theta(\pi_m - \pi_d)$. Since the patentee cannot be any worse-off by taking a patent suit, the threat to litigate an infringer is credible to the other firm. □

There may be multiple equilibria[4], but there is a unique outcome for each regime.

Proposition 1 *There is a unique equilibrium outcome for each of the four regimes:*

(I) *There is licensing at a fee of h. There is threat of infringement since there is no threat of litigation. Market will be a duopoly.*

(II) *There is no licensing. Firm U exits the market. There is threat of litigation. Market will be a monopoly.*

[4]For instance in regime (II), the outcome of "no licensing" occurs when the equilibrium licensing offer is any value too high for firm U to accept.

(III) *There is licensing at a fee of* $\theta\pi_d + h + \ell$. *There are both threats of infringement and litigation. Market will be a duopoly.*
(IV) *There is no licensing. Firm* U *infringes, firm* S *litigates, and no settlement is achieved. Market will be either a monopoly or a duopoly.*

In regime (I), firm S's litigation cost is too high and thus it will never litigate and firm U will infringe on the patent. Firm S will be better off collecting a license fee. Any fee no greater than the imitation cost is acceptable for firm U. In subgame perfect equilibrium the fee is the maximum possible, i.e., the cost of imitation. The market will be a duopoly as result of licensing. In other regimes, firm S's litigation cost is low enough so that litigation is credible. Litigation is only a threat in regime (II). In this case, firm U's litigation cost is too high and firm U chooses to exit. Because of the efficiency effect ($\pi_m > 2\pi_d$), there is no fee level firm S can offer which is acceptable to firm 2. Thus there will be no licensing and the market will be a monopoly.

In regimes (III) and (IV), firm U is willing to infringe and go to court because its litigation cost (ℓ) is also low enough, despite litigation by firm S. In regime (III), because the sum of costs of litigation and imitation is high, the joint gain from avoiding infringement and litigation is large. Firm S is able to make a licensing offer acceptable to firm U. The market will be a duopoly. A transfer of $\theta\pi_d + \ell + h$ from firm U to firm S will be made.

In regime (IV), the joint gain from avoiding infringement and litigation is not large enough to induce licensing. There will be no licensing, firm U will infringe, and there will be litigation. The market will be either a monopoly or a duopoly, depending on the outcome of litigation. Both firms incur the cost of

litigation and firm U incurs the cost of imitation also.

If the patentee does not credibly threaten to sue the infringer, the maximum licensing fee the other firm is willing to pay is only the cost of imitation. When the patentee credibly threatens to litigate, the equilibrium license fee is $\theta\pi_d + \ell + h$, reflecting the legal cost and the expected gain from litigation.

Mansfield et al. (1982) surveyed of forty-eight (patented and unpatented) product innovations of major firms in the chemical, drug, electronics, machinery industry in the Northeast U.S. Sixty percent of patented innovations in their sample were imitated within four years of their introduction. They commented, "Contrary to popular opinion, patent protection does not make entry impossible, or even unlikely." According to their estimation, imitation cost and time play an important role to hinder the infringer from entry. In our model, when θ and ℓ are low, it is still possible to have de facto effective patent protection if h is high. Thus the patentee can still appropriate a higher license fee under a legal system with no effective patent protection when h is high.

We summarize the equilibrium payoffs and welfare (social surplus) in Table 1 below. The equilibrium profit of firm X is denoted by π_X. Denote the social surpluses (consumer surplus plus producer surplus) under the monopolistic and duopolistic market structures by S_m and S_d, respectively. We assume the usual relations of consumer surplus and deadweight loss: $S_d - 2\pi_d > S_m - \pi_m$ and $S_d > S_m$.

Table 1: Equilibrium Payoffs and Social Surplus

Regime	π_S	π_U	S
(I)	$\pi_d + h$	$\pi_d - h$	S_d
(II)	π_m	0	S_m
(III)	$(1+\theta)\pi_d + \ell + h$	$(1-\theta)\pi_d - \ell - h$	S_d
(IV)	$\theta\pi_m + (1-\theta)\pi_d - L$	$(1-\theta)\pi_d - \ell - h$	$\theta S_m + (1-\theta)S_d - L - \ell - h$

The market is a duopoly for sure in regimes (I) and (III) due to licensing. In both cases, threat of infringement induces licensing. Thus the ex-post (of innovation) welfare is exactly the duopoly social surplus, S_d, and is the largest. The worst ex-post welfare performance occurs in regime (II) with the exception of when

$$S_d - S_m < \pi_d. \tag{1}$$

When this is true, regime (IV) social surplus is less than S_m in a part of regime (IV) where $L+\ell > (1-\theta)(S_d - S_m)$. Social surplus of regime (IV) can dominate monopoly social surplus because there is possibility of duopoly. But if the duopoly consumer surplus is relatively small, as in condition (1), possibility of duopoly is not enough to offset the high legal costs, making regime (IV) social surplus less than monopoly social surplus. The loss from imitation and legal cost becomes significant. Summarizing,

Proposition 2 *Ex-post welfare is maximized in regimes* (I) *and* (III). *Ex-post welfare is minimized in region* $L + \ell > (1-\theta)(S_d - S_m)$ *(subset of regime* (IV)*) if* $S_d - S_m < \pi_d$ *and in regime* (II) *otherwise.*

In regime (II), the high cost of litigation (given a level of imitation cost) or high cost of imitation (given a level of litigation cost) forces firm U to exit the market. Thus firm S becomes a monopolist. Very low litigation and imitation

costs (regime (IV)) is detrimental ex-post since both litigation and imitation will actually occur in equilibrium. Social surplus is $\theta S_m + (1-\theta)S_d - L - \ell - h$. Litigation costs are net losses to social welfare, no matter who pays them. If the litigation cost is sufficiently large, firms will be forced to license and the costs of litigation and imitation can be avoided.

We also note that for given levels of litigation and imitation costs, a legal system favoring the patentee (larger θ), will enlarge the sum of areas corresponding to regimes (II) and (IV) in Figure 2. We conclude that the ex-post welfare is reduced when the patentee is favored.

3 Incentive to Innovate and Ex-ante Efficiency

In this section we focus on the effect of the legal system (L, ℓ, and θ) on the incentives to innovate. For this purpose we employ the following simple formulation equivalent to an extra stage prior to the game considered in the previous section.

There are two firms, 1 and 2. Firm i chooses R&D intensity $x_i \geq 0$ which costs $f(x_i)$. The two intensities, x_1 and x_2, chosen simultaneously determine the probabilities $p^1(x_1, x_2)$ and $p^2(x_1, x_2)$. Probability $p^i(x_1, x_2)$ is the probability that firm i succeeds product development and attains a patent and becomes firm S. The unsuccessful rival will be firm U. The expected payoff of firm i is,

$$\Pi^i(x_1, x_2) = p^i(x_1, x_2)\pi_S + p^j(x_1, x_2)\pi_U - f(x_i). \tag{2}$$

The measurement of ex-ante welfare, the expected social surplus will be

$$E(W) = S\{p^1(x_1, x_2) + p^2(x_1, x_2)\} - f(x_1) - f(x_2). \tag{3}$$

The problem of ex-ante welfare maximization is the familiar one of balancing the tradeoff between ex-post efficiency and providing incentives to invest in R&D. This is illustrated in Table 2.

Table 2: Ex-post Welfare and Marginal Benefit of Innovation

Regime	S	MB
(I)	S_d	$2h$
(II)	S_m	π_m
(III)	S_d	$2(\theta\pi_d + \ell + h)$
(IV)	$\theta S_m + (1-\theta)S_d - L - \ell - h$	$\theta\pi_m - L + \ell + h$

The table highlights why the legal system is relevant for ex-ante efficiency. The ex-post welfare is the same in regimes (I) and (III) but the marginal benefit differs because litigation is credible in regime (III). The credible litigation is reflected in the licensing fee, increasing the difference between winning and losing the patent race.

In order to evaluate the magnitudes of tradeoffs, we resort to numerical examples by assuming the following probability function,

$$p^i(x_1, x_2) = \frac{x_i}{A + x_1 + x_2}.$$

Then

$$1 - p^1(x_1, x_2) - p^2(x_1, x_2) = \frac{A}{A + x_1 + x_2}. \tag{4}$$

The probability that nothing will be invented is increasing in the positive parameter A. Thus this parameter A indicates the degree of difficulty for the R&D to be successful. The expression (4) goes to zero when $x_1 \to +\infty$ or $x_2 \to +\infty$. We also assume a linear R&D cost function $f^i(x_i) = cx_i$ to obtain an analytical solution of the pure strategy symmetric Nash equilibrium x_i^*. (Convexity of the

objective function is guaranteed by the probability function.) It is easy to show that,

Lemma 3 *There will always be a unique pure strategy symmetric Nash equilibrium. The equilibrium intensity will be positive if expected payoff of the winner is large enough relative to cost ($\pi_S > Ac$).*

We may calculate the symmetric equilibrium x^* from the following first-order condition of maximization,

$$\frac{A + x_j(\pi_S - \pi_U)}{(A + x_1 + x_2)^2} - c = 0.$$

Using the equilibrium investment level x^*, ex-ante welfare is obtained from equation (3) for various parameter values. Each table differs by R&D technology, A, while holding the market structure constant. The numerical examples are shown in the tables below.

Table 3: A Numerical Example of Socially Optimal Patent Regime

$\pi_m = 2.2$, $\pi_d = 1$, $S_m = 3$, $S_d = 3.2$, $\theta = 0.5$, $c = 0.2$, $h = 0.05$, $A = 0.01$.

Regime	L, ℓ	x^*	$E(W)$
(I)	0.70, 0.10	0.1856	3.0418 $\surd$
(II)	0.10, 0.50	2.7500 $\surd$	1.8946
(III)	0.05, 0.05	1.5033	2.5881
(IV)	0.01, 0.01	1.4413	2.4430

Table 4: A Numerical Example of Socially Optimal Patent Regime

$\pi_m = 2.2$, $\pi_d = 1$, $S_m = 3$, $S_d = 3.2$, $\theta = 0.5$, $c = 0.2$, $h = 0.05$, $A = 1$.

Regime	L, ℓ	x^*	$E(W)$
(I)	0.70, 0.10	0.6823	1.5738
(II)	0.10, 0.50	2.6821 $\surd$	1.4558
(III)	0.05, 0.05	1.5963	1.7982 $\surd$
(IV)	0.01, 0.01	1.5549	1.6708

Table 5: A Numerical Example of Socially Optimal Patent Regime

$\pi_m = 2.2$, $\pi_d = 1$, $S_m = 3$, $S_d = 3.2$, $\theta = 0.5$, $c = 0.2$, $h = 0.05$, $A = 5$.

Regime	L, ℓ	x^*	$E(W)$
(I)	0.70, 0.10	0.0633	0.0537
(II)	0.10, 0.50	1.8357 $\surd$	0.5359 $\surd$
(III)	0.05, 0.05	0.8601	0.4751
(IV)	0.01, 0.01	0.8380	0.4255

Depending on the parameter values, any one of regimes (I) to (III) may be optimal. In all cases, regime (II), the monopoly regime, induces the highest R&D intensity. If the innovative opportunities are small (large A), then monopoly regime also maximizes ex-ante welfare. It is necessary to concentrate on providing incentive to innovate in this case. This is achieved by making the defendant's legal cost high relative to that of the plaintiff.

When R&D technology is in the middle range, then making litigation a viable option for the patentee is important in order to provide enough incentive to innovate (Table 4). If innovation is very easy even threat of litigation induces too much competition to be winner of the R&D race.

We were unable to find parameter values in which regime (IV) maximizes ex-ante welfare. Actually undertaking litigation is socially too costly. Since legal costs reduce profit for both parties, actual litigation does not help promote competition at the R&D stage as a threat of litigation can.

One of the lasting controversies in law and economics has been if intellectual property right should be established at all. For instance, Friedrich A. Hayek was against the establishment of intellectual property right (patent, copyright, trademark) since it fosters the growth of monopoly and makes market competition less effective. He questioned "whether the award of a monopoly is really

the most appropriate and effective form of reward for the kind of risk-bearing which investment in scientific research involves." (Hayek (1948))

Our findings shed light on the solution to such a long-run controversy. Hayek was reasonable in his time: When the technology level was low and there were many opportunities for technological breakthroughs, most R&D activities were done by individual researchers. Then the cost of rendering monopoly power to the innovator is higher than the associated benefit. When technology level increases and technological opportunities are exhausted, high and the costly R&D projects are performed by large firms, as it is today (Gomulka(1990)). Then it becomes necessary to provide monopoly power at the cost of ex-post efficiency and pro-patent policy becomes desirable.

This argument differs slightly from innovation vs. imitation theory of patent policy. Weak patent protection in developing economies may be desirable in order to promote spillover of information. This will reduce cost of innovation, or equivalently, increase technological opportunity. Thus patent policy is the *source* of different technological opportunities. Our results show that weak patent policy maybe socially optimal as *result* of high technological opportunity or low cost of innovation.

4 A Comparison with the English Rule

So far we have assumed that each party pays it own litigation cost independent of the verdict, known as the American rule. There is another rule, known as the English rule (Hause (1989)), which require the losing party to pay both sides' legal costs, namely $L + \ell$ in our model. We characterize the subgame perfect

Nash equilibrium when legal costs are allocated according to the English rule in the game analyzed in section 1. We again have four regimes according to the relative sizes of the legal costs and probability of the patentee winning.

Lemma 4 *We define the four following regimes under English rule:*

$$\begin{array}{lllll}
\text{(I)} & (1-\theta)(L+\ell) > \theta(\pi_m - \pi_d). & & & \\
\text{(II)} & (1-\theta)(L+\ell) \leq \theta(\pi_m - \pi_d), & \theta(L+\ell) > (1-\theta)\pi_d - h. & & \\
\text{(III)} & (1-\theta)(L+\ell) \leq \theta(\pi_m - \pi_d), & \theta(L+\ell) \leq (1-\theta)\pi_d - h. & L+\ell \geq \theta(\pi_m - 2\pi_d) - h. \\
\text{(IV)} & (1-\theta)(L+\ell) \leq \theta(\pi_m - \pi_d), & \theta(L+\ell) \leq (1-\theta)\pi_d - h, & L+\ell < \theta(\pi_m - 2\pi_d) - h.
\end{array}$$

The equilibrium strategies for each regime are:

Regime	Firm S	Firm U
(I)	(h, NL)	(A, I)
(II)	(F', LI) *for any* $F' > \pi_d$,	(NA, E)
(III)	$(\theta(\pi_d + L + \ell) + h, L)$	(A, I)
(IV)	(F', LI), *for any* $F' > \theta(\pi_d + L + \ell) + h$,	(NA, I)

Under the English rule, only the total legal cost, $\lambda = L + \ell$ is relevant. The four regimes in the (θ, λ) space is depicted in Figure 3. For comparison, we have the four regimes under the American rule in (θ, λ) space (when $\text{Ł} = \ell = \lambda/2$) in Figure 4. Again, there is a unique equilibrium outcome for each regime.

Proposition 3 *There is a unique equilibrium outcome for each of the four regimes under English rule:*

(I) *There is licensing at a fee of* h. *There is threat of infringement since there is no threat of litigation. Market will be a duopoly.*

(II) *There is no licensing. Firm* U *exits the market. There is threat of litigation. Market will be a monopoly.*

(III) *There is licensing at a fee of* $\theta(\pi_d + L + \ell) + h$. *There are both threats of infringement and litigation. Market will be a duopoly.*

(IV) *There is no licensing. Firm U infringes, firm S litigates, and no settlement is achieved. Market will be either a monopoly or a duopoly.*

The equilibrium outcomes of each regime are the same under the two rules with the exception that the licensing fee in regime (III) is $\theta(\pi_d+L+\ell)+h$ under the English rule while it was $\theta\pi_d+h+\ell$ under the American rule. Since litigation is a credible threat in this regime, the licensing fee reflects the appropriate cost of litigation. (See Proposition 1.) The ex-ante licensing condition $L+\ell \geq \theta(\pi_m - 2\pi_d) - h$ is the same under both rules. As long as the total litigation cost is high, both firms will have an incentive to avoid it through licensing under both rules. Although the relative position of each regime are the same under both rules (regime (I) is to the northwest of regimes (II) and (III), regime (II) is northeast of regime (III), etc.), the exact boundaries differ. We make the following observation concerning the licensing fee in regime (III).

Corollary 1 *In Regime (III), the licensing fees will be lower* [*equal, higher*] *under English rule if* $\theta <[=,>] \frac{\ell}{L+\ell}$.

Corollary 1 implies that when the plaintiff's probability of winning is low, switching from the American to the English rule renders the patentee a lower bargaining power since the patent owner is then more likely to pay higher (both parties') legal costs if he litigates. Yet if the plaintiff's winning probability is high, then applying the English rule can make the patentee's bargaining power even higher since an infringer is very likely to be punished by paying both sides' legal costs.

The expected social surpluses are the same in each regime under both rules since litigation costs are dead-weight losses to the society, no matter who pays for it. Therefore the analysis of optimal patent-legal system under the American rule can be applied to the system under the English rule.

5 Discussion

We have shown how a firm will use licensing to deter infringement and how the term of licensing agreement depends on the cost of litigation. Meurer (1989) has shown that a firm may license as a settlement of an infringement suit.[5] He also assumes that the probability of the original patent being upheld is less than one and there is legal cost. Licensing is used to avoid cost of litigation. Thus licensing fee reflects the legal cost. In our formulation, licensing occurs as a way to prevent imitation and thus always depends on the imitation cost. Only when threat of an infringement suit is credible, does the licensing fee depend on the litigation cost, as in Meurer's result.

We have assumed that both the cost of litigation and the probability of plaintiff victory are policy variables. It is conceivable that these variables can actually be manipulated by firms. Hu (1995) has considered the case where the probability is a function of litigation cost. Other authors have considered cases where outcome of infringement suit is affected by product choice:

Waterson (1990) has considered infringement and litigation decisions of firms where firms first choose product location to determine the outcome and cost of litigation. Thus infringement deterrence is accomplished either by litigation or

[5]For analysis of relationship between licensing before infringement and licensing as part of litigation settlement, see Aoki and Hu (1995a).

by choosing the right product location. Infringement deterrence is identified as source of product development and patenting choice of firms. In our framework, infringement deterrence is accomplished either by litigation or licensing. We identify factors of the legal system which influences another type of development, i.e., innovation.

Chou and Heller (1996) have endogenized the probability of winning by letting the second innovator (infringer) choose quality of its product and show that there is also licensing in equilibrium in order to avoid litigation. They have characterize the relationship between the legal system and terms of licensing.

We have not considered the adverse selection that a imperfect patent protection creates in the market. Horstman, MacDonald and Sliviski (1985) have addressed the question of innovation and patenting behavior when the value of a patent is uncertain. They identified the uncertainty as what determines a firms choice to patent or not to patent a successful innovation, which is not a decision choice in our model. Choi (1995) has considered a situation where the exact strength of patent protection is not known. The degree protection is revealed through sequential infringement suits and potential infringers make their entry decisions based on this revelation through time. Decision to litigate thus affects future infringement and this becomes an implicit cost of litigation.

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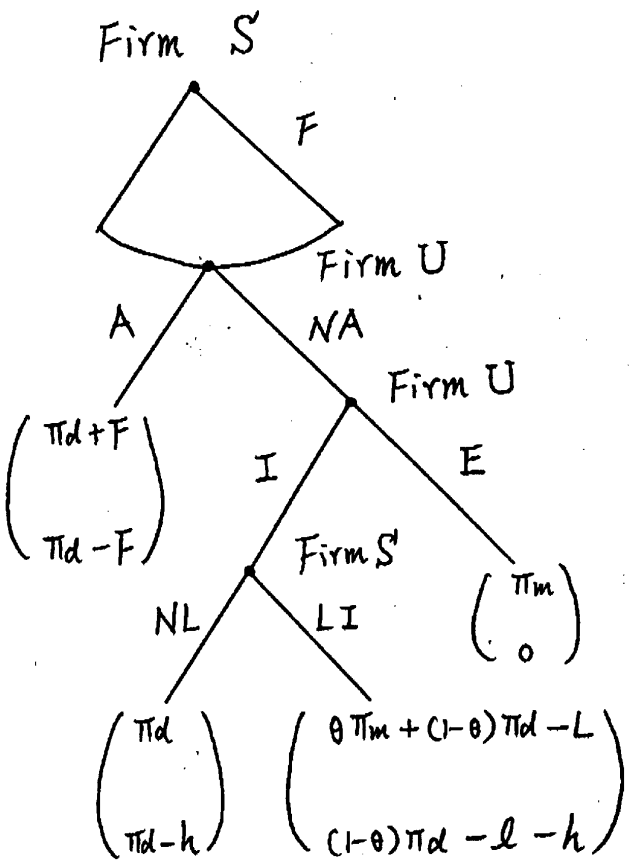

Figure 1: The Model

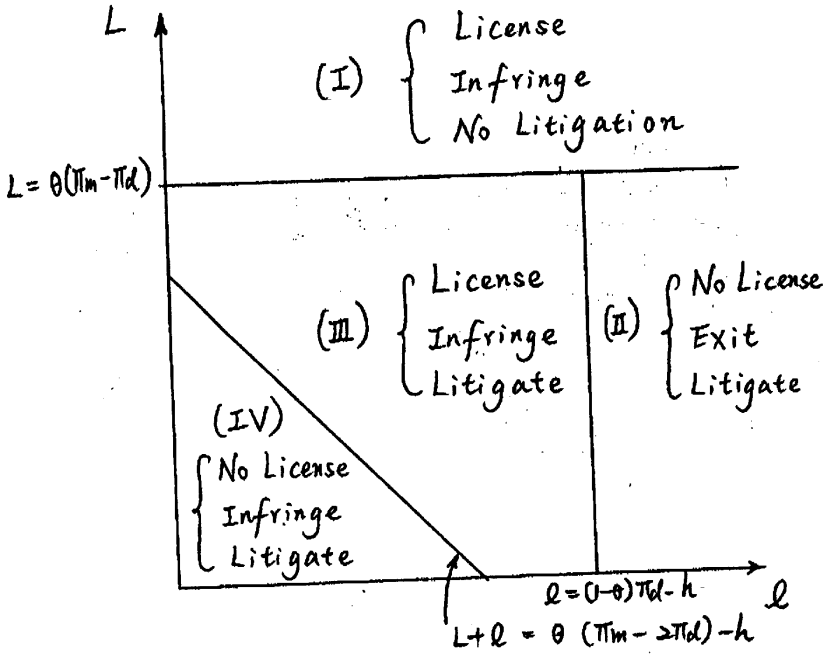

Figure 2: Equilibrium Outcomes

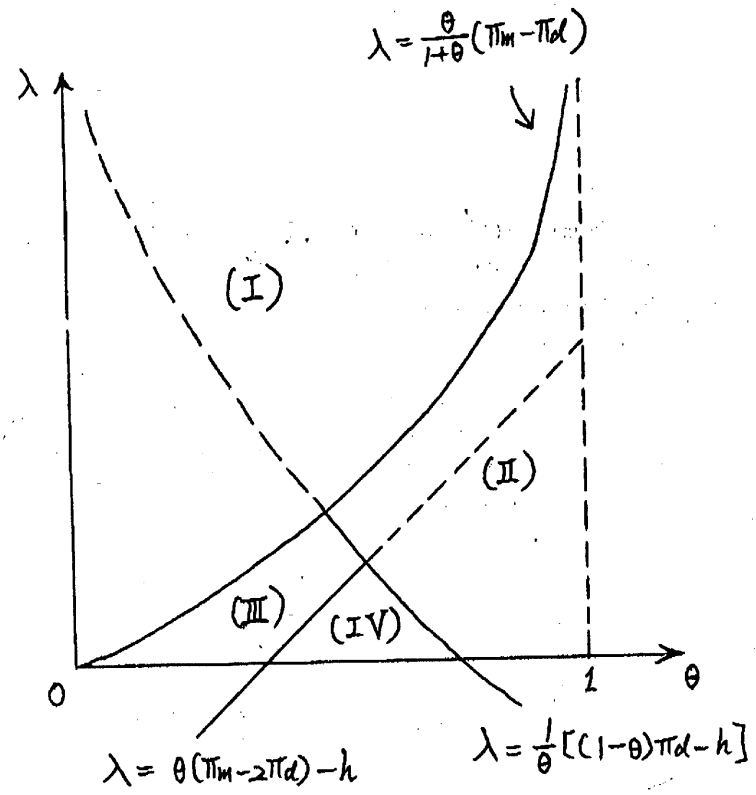

Figure 3 : Equilibrium Regimes under the English Rule ($\lambda = L + \ell$)

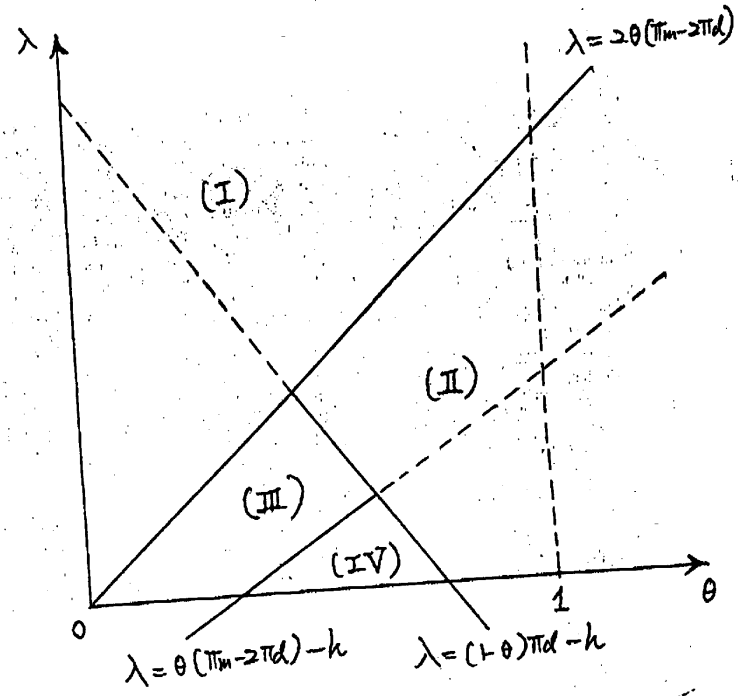

Figure 4: Equilibrium Regimes under the American Rule ($\frac{\lambda}{2} = L = \ell$)