Patent Pools and Cross-Licensing

in the Shadow of Patent Litigation*

by

Jay Pil Choi
Michigan State University

revised October 2007

Abstract

Most patent pools are formed in the shadow of patent litigation, either as an attempt to settle disputes in regard to conflicting infringement claims and the validity of patents or as a preemptive measure to prevent potential litigation. To reflect this reality, I develop a simple framework to analyze the incentives to form a patent pool or engage in cross-licensing arrangements in the presence of uncertainty about the validity and coverage of patents that makes disputes inevitable. I analyze private incentives to litigate and compare them with the social incentives. Antitrust implications of patent pools are considered.

JEL Classification: O3, L1, L4, D8, K4.
Keywords: patent pools, cross-licensing, complements and substitutes, patent litigation.

Correspondent:
Jay Pil Choi
Department of Economics
Michigan State University
East Lansing, MI 48824

Tel: 517-353-7281
Fax: 517-432-1068
E-mail: choijay@msu.edu
http://www.msu.edu/~choijay/

* I am grateful to Robert Hunt, Corinne Langinier, Josh Lerner, GianCarlo Moschini, Ines Macho-Statler, Jennifer Reinganum, Santanu Roy, and participants in various conferences and seminars for helpful comments.
I. Introduction

High-tech companies are increasingly resorting to intellectual property rights (IPR) as a source of new revenue and as a competitive weapon. The story of Texas Instruments Inc. (TI) is a case in point. In January 1986, TI filed suit against Japanese semiconductor makers NEC, Hitachi, Fujitsu, Oki Electric, and Toshiba as well as Samsung of Korea, claiming that the firms were using the patents of TI without TI’s authorization. After a lengthy legal battle, TI made these foreign companies pay royalties that amounted to $191 million in 1987, almost as much as the company’s profit from operations (Pollack, 1988). As more firms in technology-rich industries view such IPR as key corporate assets and rely on them as a profit center, the trend casts serious doubt on the patent system as a whole. Though designed to spur innovation, excessive use of patents can have the opposite effect on future advances in technology, as product developers worry about infringing and blocking patents that would limit the full utilization of new innovations.¹

Gemstar-TV Guide International Inc., a holder of more than 190 patents related to interactive TV programming, is another example of a company whose value is almost exclusively based on patent protection. In defending its patents from infringement, the firm has acquired a reputation as a litigious company.² In a recent pursuit of its IPR against EchoStar, Scientific-Atlanta, Pioneer, and SCI Systems, however, the company lost a key judgment in the International Trade Commission. As a result, Gemstar shares lost more than 75 percent of their value. As the example of Gemstar illustrates, litigation by patent-holders could be a risky move for the patent-holders themselves. The reason

¹ Heller and Eisenberg (1998) point out the downside of the patent system when too many owners hold rights in previous discoveries that constitute obstacles to future research. See also Bessen and Maskin (2004) for an analysis that demonstrates that in a dynamic setting where innovations are sequential, patent protection is not as useful for encouraging innovation as in a static setting.
² In fact, the firm itself was a child of patent litigation between Gemstar and TV Guide. The merger was approved by the Department of Justice in 2000 as a settlement of patents disputes in which Gemstar sued TV Guide for the infringement of Gemstar’s patents for on-screen interactive information about TV program listings.
this risk arises in patent litigation cases is that the alleged infringers invariably defend themselves by challenging the validity and enforceability of patents.

Most of the literature on patent protection assumes ironclad patents and no uncertainty regarding patent claims. The interpretation of the patent scope is exact and there is no need to refer to the courts over questions of the validity of the patent itself. In reality, however, the extent to which protection is provided by the patent is not precise, and even the validity of the patent itself can be challenged in the courts. Moreover, as emphasized by Scotchmer (1991), the innovation process is typically cumulative with innovations building on each other and requiring multiple patents for the practice of technology. The cumulative nature of the innovation process in conjunction with the uncertainty as to the validity and coverage of many patents makes disputes inevitable. As a result, we observe a myriad of patent infringement suits through which questions of utility, novelty, and nonobviousness are independently ruled on by a court.

The majority of these disputes, however, are settled out of court rather than litigated to a final resolution. In fact, many patent pools and cross-licensing arrangements arise as an attempt to settle disputes on conflicting claims in the litigation process or in expectation of impending litigation. In the glass bottle industry, for instance, there was litigation between Owens and Hartford between 1916 and 1924. These two companies had competing patents on automatic processes for making glass.

---

4 For instance, the "doctrine of equivalents" entitles the patented invention to cover a certain range of equivalents. However, the exact boundary of the equivalents is impossible to draw. The matter of infringement can be reasonably assumed to be decided case by case.
5 See also Green and Scotchmer (1995) and O'Donoghue, Scotchmer and Thisse (1998).
6 According to Allison and Lemley (1998), nearly half (46%) of fully litigated patents are declared invalid, which illustrates the importance of court decisions on patent validity in infringement suits.
7 Lanjouw and Schankerman (2002) report that 95% of patent lawsuits are settled prior to a court judgment.
8 According to Shapiro (2003), “[v]irtually every patent license can be viewed as a settlement of a patent dispute: the royalty rate presumably reflects the two parties’ strengths or weaknesses in patent litigation in conjunction with the licensee’s ability to invent around the patent. The same is true of cross-licenses, where net payments reflect the strength of each party’s patent portfolio along with its commercial exposure to the other’s patents.”
containers with Owens possessing a patent on the suction-feeding device while Hartford had a patent on the gob-feeding device. The companies settled their differences by agreeing to cross-license their technologies with certain use restrictions. Later in 1932, Hazel, which held a competing claim on the gob-feeding process, was defeated by Hartford in an infringement suit but was threatening to appeal. The two companies then reached a cross-licensing agreement. This event also led to license agreements between Hartford and other competing claimants on the gob-feeding process.\(^9\)

This paper develops a model of patent pools/cross-licensing in which the incentives to litigate are explicitly taken into account.\(^{10}\) As this history of the glass bottle industry illustrates, most patent pools are formed in the shadow of patent litigation as an attempt to settle disputes in regard to conflicting infringement claims and the validity of patents. To reflect this reality, I develop a simple framework to analyze the incentives to form a patent pool or engage in cross-licensing arrangements in the presence of uncertainty as to the validity and coverage of patents that makes disputes inevitable. I analyze private incentives to litigate and compare them with the social incentives. Antitrust implications of patent pools are considered.

In particular, I adopt the framework developed by Lerner and Tirole (2004) that can encompass the whole range of relationships between patents including perfectly substitutable and complementary patents. It is shown that the scope for public policy can be very different depending on the nature of relationship between patents. With ironclad patents, patent pools are pro-competitive when the relationship is relatively complementarity, as they correct an externality that leads to excessive royalty rates. Social and private incentives to form a patent pool are completely aligned. In the presence of litigation with uncertain patents, the same result holds true as long as both patents are sufficiently weak (i.e., have a low probability of being upheld by a court) and

---

\(^9\) See Areeda (1981) for a detailed account of the industry history.
\(^{10}\) See Lanjouw and Schankerman (2001) for an empirical analysis of patent litigation.
no third party challenges them. The case with substitute patents is very different. Patent pools tend to be anticompetitive and social and private incentives to form them may be quite divergent.

I also analyze patent disputes that concern the relative priority of patents to check the robustness of the results. Once again, I find that there is a divergence in private and social incentives such that patent pools are formed when patents are weak, while on welfare grounds they should be formed when patents are strong.

This paper is closely related to Shapiro (2003) who also recognizes that IPR associated with patents are inherently uncertain or imperfect, at least until they have successfully survived a challenge in court. He proposes a general rule for evaluating proposed patent settlements, which is to require that “the proposed settlement generate at least as much surplus for consumers as they would have enjoyed had the settlement not been reached and the dispute instead been resolved through litigation.” He convincingly argues that such a rule would fully respect intellectual property rights while protecting the interest of consumers. However, his paper does not analyze the incentives to litigate in the first place by just assuming that there would be patent disputes. My paper points out that the most serious case arises when both firms have weak patents and do not have any incentive to challenge each other. In such a case, public policy should be geared towards providing incentives for other concerned parties to challenge weak patents. A recent paper by Farrell and Shapiro (2005) also analyzes the licensing of patents that may be invalid to licensees who compete in a downstream product market. They show that weak patents can command surprisingly large per-unit royalties when licensed to a group of downstream oligopolists, and call for patent reform. However, they do not explicitly analyze the incentives to litigate.

11 Shapiro (2003), p. 393. See also Priest (1977) for an early analysis of patent licensing as a disguise for cartel arrangements.
12 In particular, Farrell and Shapiro (2005) show that in a symmetric Cournot oligopoly with constant marginal costs, the royalty rate for a weak patents is proportional to the number of downstream firms.
Lerner and Tirole (2004) build a model of a patent pool in which they provide a necessary and sufficient condition for a patent pool to enhance welfare. They extend their model in several directions to analyze various issues related to patent pools. These issues include the evaluation of the “external test” that does not allow inclusion of substitute patents in a pool, the rationale for the provision of automatic assignment of future related patents to the pool, and the pool members’ incentives to invent around each other’s patents. However, litigation incentives are tangential to their analysis. My paper and Lerner and Tirole (2004) focus on different aspects of patent pools and thus should be viewed as complementary.

Finally, Gilbert (2004) reviews the history of patent pools and evaluates the performance of courts through the lens of economic analysis. He makes an argument that the most important factor in the legal evaluation of patent pools and cross-licensing arrangements should be the competitive relationships among the patents involved. In his review of the legal cases, however, he finds that the most decisive factor in courts’ determination of whether patent pools have violated antitrust laws has been restrictive licensing terms. Gilbert (2004) also points out that the social return from challenges to weak patents is much higher than the private return and makes a recommendation that antitrust agencies become more proactive in this area. This paper provides theoretical support for both of his arguments.

The remainder of the paper is organized in the following way. In section II, I set up the basic model of patent pools/cross-licensing with multiple patents that takes place in the shadow of litigation. The model encompasses a wide range of relationships between patents. This includes the two polar cases of perfect substitutes and perfect complements and the whole spectrum between them. The basic presumption in the literature to date, enunciated in the Antitrust Guide Lines for the Licensing and

---

13 In a companion paper, Lerner, Strojwas, and Tirole (2003) empirically test the theoretical predictions concerning the structure of patent pools by using a sample of 63 pools established between 1895 and 2001.
Acquisition of Intellectual Property (1995), is that inclusion of complementary or essential patents in a patent pool is pro-competitive, but assembly of substitute or rival patents in a pool can eliminate competition and lead to elevated licensee fees. The model in this paper provides theoretical support for such a presumption, but also provides a few caveats in applying such a policy. Section III extends and checks the robustness of the basic model by considering the possibility that the probability of patents’ validity can be correlated. This case arises naturally if the nature of the patent dispute entails the relative priority of patents since one party’s validity automatically implies the invalidity of the other patent. Concluding remarks follow in section IV.

II. The Model of Patent Pools under Validity Uncertainty

I consider a situation of multiple patents with dispersed ownership and potentially conflicting claims. For analytical simplicity, I assume that there are two patents, A and B, which are owned by two separate firms. The relationship between these two patents could be either complementary or substitutable. Building on the framework developed by Lerner and Tirole (2004), I present a model that can encompass both perfectly substitutable and perfectly complementary patents and the full range between them.\footnote{As emphasized by Lerner and Tirole (2004), patents are rarely perfect complements or perfect substitutes.}

There is a continuum of potential licensees/users of patents. They are heterogeneous in terms of their willingness to pay for licensing, which is indexed by $\theta$. Patents are assumed to be symmetric in their contributions to licensees’ willingness to pay. More specifically, I assume that licensee type $\theta$’s gross surplus from using only one and both innovations are given by $v + \theta$ and $V + \theta$, respectively, with $V \geq v$.\footnote{The assumption of additive separability of user preferences is made to simplify the analysis. In particular, it implies that all licensees select the same set of technologies in the market. See Lerner and Tirole (2004) for a more detailed discussion of this assumption.} Thus, $\Delta = V - v$ is the incremental value of the second patent and can be interpreted as a
parameter representing substitutability/complementarity of the two patents, with a higher \( \Delta \) representing a higher degree of complementarity. For instance, \( \Delta = 0 \) is a case of perfect substitutes since it takes only one technology for the full benefit of \( V \), whereas \( \Delta = V \) is a case of perfect complements.

I assume that \( \theta \in (-\infty, 0] \), with the normalization that \( v \) and \( V \) represent the willingness to pay for one and two patents for the highest type. Let \( F \) denote the cumulative distribution of \( \theta \). Then, the demand for the bundle of both patents at royalty rate \( R \) can be written as:

(1) \[ Q(R) = \Pr (V + \theta - R \geq 0) = 1 - F(V - R) \]

I make the standard assumption that the distribution of types satisfies the monotone hazard rate condition, that is, \( F'/(1 - F) \) is strictly increasing:

(2) \[ F''(1 - F) + (F')^2 > 0 \]

This assumption ensures that the patent pool’s objective function, \( RQ(R) \), is quasi-concave and the second order condition for the maximization problem is satisfied:

(3) \[ 2Q'(R) + RQ''(R) = -2 \cdot F'(V - R) - R \cdot F''(R - V) < 0 . \]

The innovation in this paper is that I treat the intellectual property rights associated with the patents as probabilistic and explicitly consider the uncertainty in the extent of protection a patent provides in the analysis of the incentives to form a patent pool. The uncertainty about the validity of the patents is represented by the parameters \( \alpha \) and \( \beta \in [0,1] \), which are the probabilities that the court will uphold the validity of patents A and B, respectively, if they are challenged.\(^{17}\) I assume a symmetric information structure in that \( \alpha \) and \( \beta \) are common knowledge.

\(^{16}\) Using the first order condition, we can rewrite the second order condition as 
\[ -2 \cdot F'(R - V) - F''(R - V) \cdot [1 - F(V - R)] / F'(R - V) < 0 . \] The second order condition holds if the distribution \( F \) satisfies the monotone hazard rate condition. This condition is a standard assumption in the incentive literature and is satisfied by most widely used distributions; See Fudenberg and Tirole [1991, p. 267].

\(^{17}\) With probability \((1-\alpha)(1-\beta)\), for instance, both patents are invalidated. This may be the case if both patents did not reveal the relevant prior art in their applications and were awarded inappropriately.
II. 1. Patent Pools with Ironclad Patents\textsuperscript{18}

As a benchmark, I first analyze a situation in which patent protection is ironclad so the validity of the patents is not an issue. Without the possibility of patent litigation, let $r_A$ and $r_B$ denote the royalty rates charged by firm A and firm B, respectively.

As a first step in deriving the Nash equilibrium in the licensing market, consider a hypothetical situation in which licensees are \textit{constrained} to purchase \textit{both} patents. Then firm A solves the following problem given firm B’s royalty rate $r_B$:

\begin{equation}
\max_{r_A} r_A \cdot Q(r_A + r_B) .
\end{equation}

The first order condition for firm A’s optimal royalty rate $r_A$ is given by

\begin{equation}
Q(r_A + r_B) + r_A \cdot Q'(r_A + r_B) = 0 ,
\end{equation}

which implicitly defines firm A’s reaction function $r_A = \Theta_A(r_B)$. Firm B’s reaction function, $r_B = \Theta_B(r_A)$, can be derived in a similar way. The symmetric Nash equilibrium royalty rates $\hat{r}_A = \hat{r}_B = \hat{r}$ are at the intersection of these two reaction functions. The stability and uniqueness of the Nash equilibrium in the royalty rates are ensured with the monotone hazard assumption of $F$.\textsuperscript{19} The total royalty rate is given by $\hat{R} = \hat{r}_A + \hat{r}_B = 2 \hat{r}$.

The solution above, however, is predicated on the assumption that potential licensees are \textit{not} allowed to license only one technology. Thus, we must check whether the equilibrium derived will remain unchanged even if potential licensees are allowed to purchase only one technology. To prevent potential licensees from purchasing only one technology, the following condition should hold:

\begin{equation}
V - \hat{R} \geq v - \hat{r} , \text{ that is, } A \geq \hat{r}
\end{equation}

\textsuperscript{18} This subsection closely follows Lerner and Tirole (2004) and replicates some of their results.

\textsuperscript{19} The monotone hazard assumption implies that $Q'(R) + RQ''(R) < 0$. 

8
In this case, the demand margin binds for patent holders. However, if condition (6) is violated, the competitive margin binds. Consequently, potential licensees will purchase only one technology if both firms charge the royalty rate of $\hat{r}$, and the excluded firm will have incentives to cut its price below that of the competitor. Then, the only equilibrium that can be sustained is $r_A = r_B = \Delta$.

Thus, the equilibrium royalty rate is given by $r^\ast = \min(\Delta, \hat{r})$, with both firms having positive sales.

In contrast, if firms A and B form a patent pool and practice package licensing, the optimal royalty rate is derived by solving

$\hbox{Max}_R R \cdot Q(R)$

Let $\tilde{R}^\ast$ be the optimal royalty rate for the pool. Then, $\tilde{R}^\ast$ satisfies the following first order condition:

$Q(\tilde{R}^\ast) + \tilde{R}^\ast Q'(\tilde{R}^\ast) = 0$

Proposition 1 shows that with the formation of patent pools, the overall royalty rate for the licensees can be either lower or higher depending on the relationship between the two technologies; patent pools tend to be procompetitive as patents become more complementary.

**Proposition 1 (Lerner-Tirole, 2004).** There is a critical level of $\Delta$ such that $R^\ast = r_A^\ast + r_B^\ast > \tilde{R}^\ast$ if and only if $\Delta > \Delta^\ast$, where $\Delta^\ast = \tilde{R}^\ast/2$. That is, the total royalty rate decreases with the formation of the patent pool if and only if $\Delta > \Delta^\ast = \tilde{R}^\ast/2$. In such a case, social incentives and private incentives to form a patent pool are aligned. Otherwise, patent pools reduce social welfare.

---

20 The demand margin binds when an increase in one firm’s price induces a reduction of its demand, but not to the exclusion of its technology from users’ choice of technologies.

21 Variables associated with patent pools are denoted with a tilde.
Proof. If $\Delta \geq \hat{r}$ and the demand margin binds, the Nash equilibrium royalty rates $r_A^* = r_B^* = \hat{r}$ satisfy
\[
2Q(r_A^* + r_B^*) + (r_A^* + r_B^*) \cdot Q'(r_A^* + r_B^*) = 0
\]
Evaluating the first order condition for the patent pool (8) at $R^* = r_A^* + r_B^*$ yields
\[
Q(r_A^* + r_B^*) + (r_A^* + r_B^*) \cdot Q'(r_A^* + r_B^*) = -Q(r_A^* + r_B^*) < 0
\]
This implies that $R^* = r_A^* + r_B^* = 2\hat{r} > \tilde{R}^*$.  

If $\Delta < \hat{r}$ and the competitive margin binds, the Nash equilibrium royalty rates $r_A^* = r_B^* = \Delta$, with $R^* = 2\Delta$. Since $2\hat{r} > \tilde{R}^*$, we have the desired result that that $R^* = r_A^* + r_B^* = 2\Delta > \tilde{R}^*$ if and only if $\Delta > \Delta^* = \tilde{R}^*/2$. See also Figure 1. Q.E.D.

As an example, consider a case where $\theta$ is uniformly distributed between minus infinity and zero with population density of one. This generates a linear demand curve for licensing, $Q(R) = V - R$. It can be easily verified that the optimal royalty rate for the patent pool, $\tilde{R}^*$, is given by $V/2$ in this case. Without a patent pool, the competitive margin binds and the symmetric equilibrium royalty rate is given by $r^* = \Delta$, if $\Delta < V/3$. Otherwise, the demand margin binds and the equilibrium royalty rate is given by $r^* = V/3$. The critical value of $\Delta$ is given by $\Delta^* = V/4$.

The result that patent pools can be welfare enhancing when technologies become more complementary and the demand margin binds is a generalization of the well-known result that dates back to Cournot’s (1927) analysis of the complementary monopoly problem. When the demand margin binds, without coordination in pricing each patentee does not internalize the increase in the other patentee’s profits when the demand for the package is increased by a reduction in its price. Thus, a patent pool can decrease the overall royalty rates for the package and simultaneously increase both patentees’ profits and consumer surplus. Consequently, social welfare also increases. As a result an argument can be made for lenient treatment of a patent pool due to its pro-competitive effects with complementary patents. In the next subsection, however, I consider the case
where patent protection is not perfect. In this case, I show that more caution is needed in granting blanket immunity even towards patent pools comprised of complementary patents, especially when weak patents are involved.

Figure 1. Patent Pools with Ironclad Patents
II. 2. Uncertain Patents and Litigation Incentives

To investigate implications of uncertain patents, I now consider the possibility that the scope of the patent is not exact and that the validity itself can be challenged. Let me analyze each firm’s incentives to challenge the validity of the other firm’s patent. If one firm, say A, challenges firm B’s patent, it is assumed that it is optimal for firm B to counterattack by challenging the validity of firm A’s patent. This assumption will hold if there are economies of scope in litigations since the counter-suit will not significantly add to the cost of litigation beyond that of defending its own patent. In fact, in most litigation cases where the accused also has patents, the accused party invariably lodges a counter-suit against the challengers. This assumption implies that attacking another firm’s patent validity or infringement creates a risk of having one’s own patent invalidated in the process. For instance, when Hewlett-Packard recently sued data storage company EMC Corp. for infringing some of its patents, EMC countersued H-P with its own patent infringement claims.\(^{22}\)

I assume that the probability of validity of each patent is independent of the other. This would be an appropriate assumption with complementary patents or if the technologies of the two patents were developed by taking completely different research approaches in the case of substitute patents. As an example, consider a gene therapy product to treat a disease. There are two alternative methods developed to get genes into cells. Sandoz developed the *ex vivo* process in which cells are removed form the body, the genetic material is inserted, and the cells are returned to the body. Ciba Geigy, in contrast, developed the *in vivo* process in which the genetic material is inserted while the

---

\(^{22}\) Another example is the recent patent dispute between Nikon and ASML involving lithography equipment, which is used to print circuits on silicon wafers that become semiconductors or chips. When Nikon filed a complaint against ASML claiming the Dutch company infringed on seven Nikon patents, ASML responded by claiming that the respective Nikon patents in question were invalid, and a counterclaim was filed alleging that Nikon infringed on four ASML patents (see Chappell, 2002).
cells remain in the body. Therefore, it would be a reasonable assumption that the probability of validity of each patent is independent of the other.\textsuperscript{23}

“Standing to Sue”

One issue to consider in my analysis is if the firms in patent disputes have legal “standing to sue,” especially for complementary patents. One natural way to interpret the situation is to consider a case of potentially “blocking” patents. For instance, technology A is a broad patent on a basic research tool whose commercial value is zero in itself. Technology B is an application of technology A that enables commercialization of the latter with a value of $V$. Thus, B is a subservient patent which cannot be practiced without a license from the holder of patent A if B is found to infringe on patent A. In such a scenario, we have a case of perfect complementarity: the value of each patent alone is zero ($v = 0$) whereas they generate the value of $V$ taken together ($\Delta = V$). Such a blocking relationship confers the patent-holder A standing to sue B. Once A lodges a patent suit against B, the optimal response of B is to invalidate patent A.

Let $\Pi^M$ and $\Pi^D$, respectively, denote the patent-holder’s profits when it is the only firm who has a patent and when it is one of the two firms who have patents. Notice that both profits depend on $\Delta$. If a firm is the only patent holder after the other patent is invalidated and now freely available, potential licensees will buy the technology if and only if

$$V + \theta - r > \max [v + \theta, 0]$$

Thus, the demand for the monopolistic supplier of the patent is given by:

$$q^M(r) = \begin{cases} Q(r), & \text{if } r \leq \Delta \\ 0, & \text{if } r > \Delta \end{cases}$$

\textsuperscript{23} In the next section, I consider the case where disputes are mainly on the issue of priority and one party’s validity means the other party’s patent being revoked.
This implies that the pricing decision for the monopolistic supplier of the patent is constrained by the existence of the other freely available technology if \( \Delta < \tilde{R}^* \). The optimal price for the monopolist is given by:

\[
\rho^M = \begin{cases} 
\Delta, & \text{if } \Delta < \tilde{R}^* \\
\tilde{R}^*, & \text{if } \Delta \geq \tilde{R}^*
\end{cases}
\]

The profit for the monopolistic supplier of the patent is given by:

\[
\Pi^M = \begin{cases} 
\Delta Q(\Delta), & \text{if } \Delta < \tilde{R}^* \\
\tilde{R}^* Q(\tilde{R}^*), & \text{if } \Delta \geq \tilde{R}^*
\end{cases}
\]

If both firms hold a patent,

\[
\Pi^D = r^* Q(2r^*) = \begin{cases} 
\Delta Q(2\Delta), & \text{if } \Delta < \hat{r} \\
\hat{r} Q(2\hat{r}), & \text{if } \Delta \geq \hat{r}
\end{cases}
\]

It can be easily verified that \( \Pi^M > \Pi^D \) for all values of \( \Delta \in [0, V] \). Let the legal costs of litigation be denoted by \( \chi \), which are assumed to be the same for both firms.

Each firm’s profits without litigation are given by:

\[
V^{NL}_A = V^{NL}_B = \Pi^D
\]

If there is litigation concerning the validity of the patents, each firm’s profits are given by

\[
V^L_A = \alpha \left[ \beta \Pi^D + (1-\beta) \Pi^M \right] - \chi, \quad V^L_B = \beta \left[ \alpha \Pi^D + (1-\alpha) \Pi^M \right] - \chi
\]

Firm A will have an incentive to litigate if

\[
\Lambda_A = V^L_A - V^{NL}_A = \{ \alpha \left[ \beta \Pi^D + (1-\beta) \Pi^M \right] - \chi \} - \Pi^D \geq 0
\]

It can be easily verified that

\[
\frac{\partial \Lambda_A}{\partial \alpha} = \beta \Pi^D + (1-\beta) \Pi^M > 0
\]

\[
\frac{\partial \Lambda_A}{\partial \beta} = \alpha \left[ \Pi^D - \Pi^M \right] < 0.
\]
Thus, firm A’s incentives to litigate increase with the strength of its own patent and decrease with the strength of the other firm’s patent. Given the other firm’s patent strength, $\beta$, firm A will litigate if

\[
\alpha \geq \psi_A(\beta) = \frac{\Pi_D + \chi}{\beta \Pi_D + (1 - \beta) \Pi_M}
\]

It can be easily verified that $\psi_A(\beta)$ is upward sloping and convex in $\beta$.

Similarly, firm B will have incentive to litigate if

\[
\Lambda_B = V_B^L - V_B^N = \{\beta \left[ \alpha \Pi_D + (1 - \alpha) \Pi_M \right] - \chi} - \Pi_D \geq 0
\]

Given the strength of firm A’s patent, $\alpha$, firm B will initiate litigation if

\[
\beta > \psi_B(\alpha) = \frac{\Pi_D + \chi}{\alpha \Pi_D + (1 - \alpha) \Pi_M}
\]

Let $L_A$ and $L_B$ denote the set of $(\alpha, \beta)$ that satisfies conditions (10) and (12), respectively, i.e.,

\[
L_A = \{ (\alpha, \beta) \in [0,1]^2 | \alpha \left[ \beta \Pi_D + (1 - \beta) \Pi_M \right] - \chi > \Pi_D \}
\]

\[
L_B = \{ (\alpha, \beta) \in [0,1]^2 | \beta \left[ \alpha \Pi_D + (1 - \alpha) \Pi_M \right] - \chi > \Pi_D \}
\]

Litigation will take place if either firm has an incentive to litigate, i.e., $(\alpha, \beta) \in L$, where $L = L_A \cup L_B$. There will be no litigation only when neither firm has any incentive to litigate. This is when $\alpha$ and $\beta$ are low, that is, both firms have weak patents and $(\alpha, \beta) \in NL$, where $NL = L ^C = [0,1]^2 - L$.

Now let me analyze social incentives to litigate. Let $CS(R)$ be the level of consumer/user surplus when the royalty rate for the bundle of both patents is given by $R$, where $CS(R) = \int_R^V Q(p)dp = \int_R^V \left[ 1 - F(p - V) \right]dp$ and $CS'(R) < 0$. If there is litigation, the downstream market price depends on the outcome of the litigation. For instance, if the outcome of litigation is that both patents are invalidated, both technologies are freely available at the royalty rate of zero. Instead, if both patents are deemed valid, the royalty rate would be $R^* = r_A^* + r_B^*$ as in the case of no litigation. If only one of them is
deemed valid, the holder of the valid patent will set the royalty rate at \( r^M = \Delta \) if \( \Delta < \tilde{R}^* \) and \( r^M = \tilde{R}^* \) if \( \Delta \geq \tilde{R}^* \).

Let me follow the standard practice of using the sum of consumer surplus and industry profits as a measure of social welfare. Let \( W^M \), \( W^D \) and \( W^C \) denote the welfare levels when the (upstream) market structures are monopoly (i.e., only one patent is deemed valid), duopoly (both patents are valid), and perfectly competitive (both patents are invalidated), respectively.

\[
\begin{align*}
W^M &= \Pi^M + CS(r^M) = \begin{cases} 
\Delta Q(\Delta) + CS(\Delta), & \text{if } \Delta < \tilde{R}^* \\
\tilde{R}^* Q(\tilde{R}^*) + CS(\tilde{R}^*), & \text{if } \Delta \geq \tilde{R}^*
\end{cases} \\
W^D &= 2 \Pi^D + CS(R^*) = \begin{cases} 
2\Delta Q(2\Delta) + CS(2\Delta), & \text{if } \Delta < \hat{r} \\
2\hat{r} Q(2\hat{r}) + CS(2\hat{r}), & \text{if } \Delta \geq \hat{r}
\end{cases} \\
W^C &= CS(0)
\end{align*}
\]

We have \( W^D < W^M < W^C \) since \( \hat{r} < \tilde{R}^* < 2 \hat{r} \). That is, social welfare increases as more patents are invalidated and become freely available.

Without a patent pool, the expected social welfare associated with litigation is given by

\[
(15) \quad SW^L = [\alpha \beta W^D + (\alpha - 2\alpha \beta + \beta)W^M + (1 - \alpha)(1 - \beta)W^C] - 2\chi
\]

If there is no litigation and no patent pool, the market price at the downstream stage is \( R^* = r_A^* + r_B^* \). Social welfare without litigation is then given by

\[
(16) \quad SW^{NL} = W^D = 2 \Pi^D + CS(R^*)
\]

Therefore, the social incentive to litigate is given by

\[
(17) \quad \Lambda_S = SW^L - SW^{NL} = (1 - \alpha \beta) [W^M - W^D] + (1 - \alpha)(1 - \beta) [W^C - W^M] - 2\chi
\]

It is not expected that private incentives to litigate would coincide with social incentives. In particular, if the cost of litigation (\( \chi \)) is relatively low \( \Lambda_S > 0 \), and patent disputes through litigation are socially beneficial since they can lead to invalidation of patents and less market power. This implies that when both patents are weak the private and social incentives will always diverge since \( \lim_{\alpha \to 0} \Lambda_A = \lim_{\beta \to 0} \Lambda_B = -\Pi^D < 0 \). We can conclude
that when patents are weak, there will be a serious lack of incentives to litigate among patent-holders since they accommodate each other by adopting the policy of “live and let live.”

II. 3. Patent Pools in the Presence of Uncertain Patents

The analysis in the previous subsection applies to the case where the formation of a patent pool is not allowed, say, due to restrictions by antitrust authorities. If the formation of a patent pool is allowed without any restrictions, the only role of litigation is to set “threat points” for negotiating licenses. The terms of patent pools are negotiated in the shadow of what would happen otherwise, and in this way the expectation of litigation outcomes determines how the royalties are shared between pool members.

Let me analyze the private incentives to form a patent pool and how royalty income is divided between the two firms. I assume that the surplus from negotiation is equally split between the two firms as in Green and Scotchmer (1995). When the parameters \((\alpha, \beta)\) belong to the set \(\mathcal{NL}\), such that both firms have no incentive to litigate, both will get the same royalty rate \(\tilde{R} */2\) regardless of their relative patent strengths. When \((\alpha, \beta)\in \mathcal{L}\), there will be litigation in the absence of a patent pool. In this case, the division of the royalty income reflects the relative strength of the patents. Let \(\kappa\) and \((1-\kappa)\) denote the proportions of the royalty income that accrue to firm A and B, respectively. Then, the bargaining solution with equal surplus implies that

\[
\kappa \Pi^M - \{\alpha [\beta \Pi^D + (1-\beta) \Pi^M] - \chi\} = (1-\kappa) \Pi^M - \{\beta [\alpha \Pi^D + (1-\alpha) \Pi^M] - \chi\}.
\]

This yields

\[
\kappa = \frac{1 + \alpha - \beta}{2}.
\]

**Proposition 2.** Under bargaining with equal surplus, the royalty rates are the same for both firms at \(\tilde{R} */2\) when both firms have weak patents, that is, \((\alpha, \beta)\in \mathcal{NL}\). If \((\alpha, \beta)\in \mathcal{L}\) and at least one of the firms has incentives to litigate, the royalty rates reflect the relative strength of the patents (i.e., the probability of patent’s validity) in the pool.
Example. Once again, consider a case where \( \theta \) is uniformly distributed between minus infinity and zero with density one, which generates a linear demand curve for licensing, \( Q(P) = V - P \). Assume that \( \Delta = V/2 \). In this case, the profits for the monopoly and duopoly are given by \( \Pi_M = \frac{V^2}{4} \) and \( \Pi_D = \frac{V^2}{9} \), respectively. For simplicity, assume that the cost of litigation is negligible with \( \chi = 0 \). Suppose that \( \beta = 1/5 \). Then, it can be easily verified that firm B has no incentive to initiate litigation, and firm A will have an incentive to litigate if and only if \( \alpha \geq 1/2 \). Thus, firm A and B will share the monopoly profit equally and the division of royalty income is invariant in \( \alpha \) as long as \( \alpha < 1/2 \).

However, if \( \alpha \geq 1/2 \) the division of royalties reflects the relative strength of the two patents. As can be seen in Figure 2, the value of patents can be discontinuous in patent strength at the point of regime change.

![Figure 2: Firm A’s Share of Royalty Income as a function of \( \alpha \) with \( \beta = 1/5 \)](image-url)
In a model of patent dispute, Shapiro (2003) also points out the possibility that the value of a patent is not linear in patent strength when settlement is possible. However, the reason for non-linearity is completely different. He considers a patent dispute between the incumbent who holds a patent and the entrant who challenges it. Thus, there is only one patent involved in the dispute. More importantly, his paper does not analyze the incentives to litigate in the first place. The value of a patent is always continuous and increasing in patent strength even though it is non-linear. My model indicates that the consideration of litigation incentives introduces a discontinuity in the division of royalty incomes.

III. Optimal Antitrust Policy on Patent Pools

I now consider the optimal antitrust policy concerning patent pools in a situation where the social planner’s only decision is whether to approve patent pools or not. With probabilistic patent rights, I need to make a distinction between \textit{ex ante} and \textit{ex post} policy, depending on the information available at the time of the policy decision. Ex ante policy decisions are the ones made when patents considered for patent pools have not yet been contested in the court and thus their validities are uncertain. In contrast, ex post policy decisions are the ones made after the validities of patents in consideration have been contested in court and thus there is no uncertainty about their validities. I will call patent pools formed before a patent validity check in court \textit{ex ante patent pools}. Patent pools formed after litigation are called \textit{ex post patent pools}.

III. 1. Ex Post Optimal Patent Pool Policy

Once patents in consideration are contested in court, they are either held valid or invalidated, eliminating any uncertainty about their validities. It is obvious that the \textit{ex post} optimal patent pool policy requires that no invalidated patents be included in the
pool. Thus, the only relevant case to consider is the one in which both patents are held valid. Notice that this case is equivalent to the case of ironclad patents we analyzed earlier. Since ex post decisions are made with respect to ironclad patents, the analysis of subsection II.1 applies. That is, the optimal ex post patent pool policy is to allow patent pools if and only if $\Delta > \Delta^*$, where $\Delta^* = \widetilde{R}^*/2$ (see Proposition 1).

This implies that with the optimal ex post patent pool policy in place, each firm’s ex post profit and social welfare when both patents are found to be valid are respectively given by:

$$
\Pi = \begin{cases} 
\Pi^D = \rho^* Q(2r^*) = \Delta Q(2\Delta), & \text{if } \Delta < \Delta^* = \frac{\widetilde{R}^*}{2} (< \hat{r}) \\
\frac{\tilde{R}^* Q(\tilde{R}^*)}{2}, & \text{if } \Delta \geq \Delta^*
\end{cases}
$$

$$
\tilde{W}^D = \begin{cases} 
\tilde{W}^D = 2\Pi^D + CS(R^*) = 2\Delta Q(2\Delta) + CS(2\Delta), & \text{if } \Delta < \Delta^* \\
\tilde{R}^* Q(\tilde{R}^*) + CS(\tilde{R}^*), & \text{if } \Delta \geq \Delta^*
\end{cases}
$$

### III. 2. Ex Ante Optimal Patent Pool Policy

Now I turn my attention to ex ante optimal policy. Obviously, the analysis of ex ante policy depends crucially on a counterfactual analysis of what would happen in the market if the patent pool is not approved. In particular, it depends on if any firm would have an incentive to litigate in the absence of patent pools, which in turn depends on ex post patent pool policy, i.e., what is allowed if both firms’ patents are validated. I assume that ex post patent policy is optimal; that is, a patent pool is allowed ex post if and only if both patents are upheld to be valid and $\Delta > \Delta^*$.24

---

24 In the previous version of the paper, I assumed no ex post patent pool and derived qualitatively the same results. See Choi (2003) for more details.
To analyze the social incentives to form patent pools, I need to consider firms’ incentives to litigate in the absence of an *ex ante* patent pool. By proceeding as in subsection II.2, I can easily derive the condition for firm A to litigate as

\[ (10)' \quad \alpha \geq \Psi_A (\beta) = \frac{\Pi^D + \chi}{\beta \Pi^D + (1 - \beta) \Pi^M}, \]

where a tilde above variables signifies that ex post optimal patent policy is reflected in the litigation decision. Similarly, firm B will initiate litigation if

\[ (12)' \quad \beta \geq \Psi_B (\alpha) = \frac{\Pi^D + \chi}{\alpha \Pi^D + (1 - \alpha) \Pi^M}. \]

Let \( L_A \) and \( L_B \) denote the set of \((\alpha, \beta)\) that satisfies conditions (10)' and (12)', respectively, i.e.,

\[ (13)' \quad L_A = \{(\alpha, \beta) \in [0,1]^2 | \alpha [\beta \Pi^D + (1 - \beta) \Pi^M] - \chi > \Pi^D\}, \]

\[ L_B = \{(\alpha, \beta) \in [0,1]^2 | \beta [\alpha \Pi^D + (1 - \alpha) \Pi^M] - \chi > \Pi^D\}. \]

Once again, litigation will take place if either firm has an incentive to litigate, i.e., \((\alpha, \beta) \in \tilde{L}\), where \( \tilde{L} = L_A \cup L_B \).

I consider two cases to analyze the social incentives to form patent pools.

**Case 1.** \((\alpha, \beta) \in \tilde{L}\)

In this case, if the *ex ante* patent pool is not allowed there will be patent litigation challenging the validity of each other’s patent. Let \( \tilde{SW} \) denote the level of social welfare that prevails with the formation of an *ex ante* patent pool. With a patent pool, the royalty rate for the bundle of both technologies is given by \( \tilde{R}^* \), regardless of \( \Delta \). This implies that \( \tilde{SW} = \tilde{W}^M \), where \( \tilde{W}^M = \tilde{R}^*Q(\tilde{R}^*) + CS(\tilde{R}^*) \).

Therefore, *ex ante* patent pools should be allowed if

\[ (19) \quad \tilde{SW} - SW^L = \tilde{W}^M - \{[\alpha \beta \tilde{W}^D + (\alpha - 2\alpha\beta + \beta)W^M + (1 - \alpha)(1 - \beta)W^C] - 2\chi\} \]

\[ = \alpha \beta [W^M - \tilde{W}^D] - (1 - \alpha)(1 - \beta)[W^C - W^M] + [\tilde{W}^M - W^M] + 2\chi > 0 \]
The following lemma shows that if the litigation cost is negligible (i.e., $\chi \approx 0$), \textit{ex ante} patent pools should never be allowed as long as the \textit{ex post} optimal patent pool policy is in place.

**Lemma.** If the patent policy is \textit{ex post} optimal and the litigation cost is negligible, \textit{ex ante} patent pools should not be allowed.

**Proof.** I prove this by showing that condition (19) can never be satisfied if $\chi \approx 0$. To demonstrate this, I consider three sub-cases depending on the magnitude of $\Delta$.

(i) $\Delta < \tilde{R}^*/2$ ($< \hat{r}$)

With a negligible litigation cost, condition (19) can be rewritten as:

\[
\beta > \frac{[W^M - \tilde{W}^M] + (1-\alpha)[W^C - W^M]}{\alpha[W^M - \tilde{W}^D] + (1-\alpha)[W^C - W^M]}
\]

Notice that we have $W^C > W^M > \tilde{W}^D = W^D > \tilde{W}^M$ for $\Delta < \tilde{R}^*/2$. Therefore, the RHS of inequality (20) is larger than 1. As a result, condition (20) cannot be satisfied. This implies that if the two technologies are very close substitutes (more precisely, if $\Delta < \tilde{R}^*/2$), patent pools should never be allowed. The reason is that even in the worst possible scenario under litigation, which is both patents being held valid, social welfare is still higher than when under an \textit{ex ante} patent pool. This result is consistent with the conventional wisdom that patent pools should not be allowed for close substitutes.

(ii) $\tilde{R}^*/2 < \Delta < \tilde{R}^*$

In this case, we have $W^C > W^M > \tilde{W}^D = \tilde{W}^M > W^D$. Therefore, with $\chi \approx 0$,

\[
\tilde{S}W - SW^L \approx - (1-\alpha)(1-\beta)[W^M - \tilde{W}^D] - (1-\alpha)(1-\beta)[W^C - W^M] < 0.
\]

(iii) $\Delta \geq \tilde{R}^*$

For $\Delta \geq \tilde{R}^*$, we have $W^C > M = \tilde{W}^M = \tilde{W}^D$. This implies that with $\chi \approx 0$,

\[
\tilde{S}W - SW^L \approx - (1-\alpha)(1-\beta)[W^C - W^M] < 0.
\]
Sub-cases of (ii) and (iii) indicate that \textit{ex ante} patent pools should not be allowed even if the two technologies are complementary (more precisely, even if $\Delta > \tilde{R}^*/2$) as long as the litigation costs are negligible. In other words, patent pools should be allowed \textit{only after} the validities of all patents are certified in courts and they are sufficiently complementary (i.e., $\Delta > \tilde{R}^*/2$). Thus, provided that the \textit{ex post} optimal patent pool policy is in place, the only way to justify \textit{ex ante} patent pools is significant litigation costs.

Case 2. $(\alpha, \beta) \in \tilde{N}L$

In this case, if the patent pool is not allowed, there will be no patent litigation. Thus, policy concerning patent pools should be the same as that under ironclad patents analyzed before. The social welfare without a patent pool is given by $SW^{NL} = W^D = 2 \Pi^D + CS(R^*)$ whereas the social welfare with a patent pool is $\tilde{W}^M$. This implies that patent pools should be allowed in this case if $\Delta > \Delta^* = \tilde{R}^*/2$ (see Proposition 1).

The following proposition summarizes the optimal patent pool policy.

\textbf{Proposition 3.} If $(\alpha, \beta) \in \tilde{L}$ and the litigation cost is negligible, \textit{ex ante} patent pools should not be allowed. \textit{Ex post} litigation, patent pools should be allowed only if both patents are found to be valid and $\Delta > \Delta^*$. If $(\alpha, \beta) \in \tilde{NL}$, \textit{ex ante} patent pools should be allowed if $\Delta > \Delta^*$.

---

\textsuperscript{25}The previous version of the paper (Choi, 2003) considers a more limited patent pool policy in which the patent pool decision cannot be contingent on the outcome of patent litigation and is made only at the \textit{ex ante} stage. In such a case, there are cases in which \textit{ex ante} patent pool should be allowed. In particular, with the linear demand example considered earlier, I show that if $\Delta \geq \frac{V}{2}$, patent pools should be allowed when $\beta \geq \frac{1 - \alpha}{1 - \frac{2}{9} \frac{\alpha}{\beta}}$. 

---

23
To be more concrete, let me again consider a specific example of uniform
distribution which yields a linear demand for the bundle of the two technologies, \( Q(P) = V - P \). Here, firms A and B will set the royalty rate of \( r_A^* = r_B^* = \Delta \) if \( \Delta < V/3 \), and \( r_A^* = r_B^* = V/3 \) if \( \Delta \geq V/3 \). If one of the patents is invalidated, the other patent-holder as a monopolist sets the royalty rate of \( r^M = \Delta \) if \( \Delta < V/2 \) , and \( r^M = V/2 \) if \( \Delta \geq V/2 \). The optimal royalty rate under a patent pool \( \tilde{R}^* = V/2 \). The critical value \( \Delta^* = V/4 \). This leads to

\[
\begin{align*}
\Pi^M &= \begin{cases} 
\Delta(1-\Delta), & \text{if } \Delta < V/2 \\
V^2/4, & \text{if } \Delta \geq V/2 
\end{cases} \\
\Pi^D &= \begin{cases} 
\Delta(V-2\Delta), & \text{if } \Delta < V/3 \\
V^2/9, & \text{if } \Delta \geq V/3 
\end{cases} \\
\Pi^\bar{D} &= \begin{cases} 
\Delta(V-2\Delta), & \text{if } \Delta < V/4 \\
V^2/8, & \text{if } \Delta \geq V/4 
\end{cases} \\
W^M &= \Pi^M + CS(r^M) = \begin{cases} 
\frac{V^2}{2} - \frac{\Delta^2}{2}, & \text{if } \Delta < V/2 \\
3V^2/8, & \text{if } \Delta \geq V/2 
\end{cases} \\
W^C &= CS(0) = V^2/2 \\
W^\bar{M} &= \tilde{R}^* Q(\tilde{R}^*) + CS(\tilde{R}^*) = 3V^2/8 \\
W^\bar{D} &= \begin{cases} 
W^D = 2\Pi^D + CS(\tilde{R}^*) = \frac{V^2}{2} - 2\Delta^2, & \text{if } \Delta < V/4 \\
\tilde{R}^* Q(\tilde{R}^*) + CS(\tilde{R}^*) = 3V^2/8, & \text{if } \Delta \geq V/4 
\end{cases}
\end{align*}
\]

To demonstrate the divergence in social and private incentives to form \textit{ex ante} patent pools, consider the case where \( \Delta \geq V/2 \). In this case, it easily be shown that litigation takes place if \( \beta \geq \frac{8}{9-2\alpha} \) or \( \alpha \geq \frac{8}{9-2\beta} \) with negligible litigation costs. The areas of incongruence between the social and private incentives are represented as dotted
ones in Figure 3. In the dotted areas, social welfare increases with litigation and one of the two firms will have incentives to litigate if patent pools are not allowed. Thus, the optimal policy is to disallow patent pools whereas private firms would always prefer to form patent pools.

\[
\alpha = \Psi_A(\beta) = \frac{8}{9(2 - \beta)}
\]

\[
\beta = \Psi_B(\alpha) = \frac{8}{9(2 - \alpha)}
\]

Figure 3: Discrepancy between Private and Social Incentives to Litigate (\(\Delta \geq V/2\))

Proposition 3 indicates that when no firm has incentive to litigate, we have a paradoxical result with complementary patents (i.e., \(\Delta > \Delta^* = \tilde{R}^*/2\)); patent pools should
be allowed and the monopoly be preserved exactly when the patents are most suspect and have little value (the shaded area in Figure 3). The reason is that unless there is a third party that has a stake in the invalidation of the patents the alternative is the perpetuation of duopoly, which is worse than monopoly in the case of complementary patents. Public policy in this case should be geared towards providing incentives for third parties to invalidate weak patents.

My discussion so far has focused on the case in which litigation costs are negligible. The consideration of litigation costs changes my welfare results in a predictable way. In particular, there can be regions of parameters in which ex ante patent pools are welfare-enhancing especially when litigation costs are significant. However, it does not change the main message of the paper, which is that ex ante patent pools should not be allowed for patents of suspect validity if firms have incentives to litigate.

According to a recent survey by the American Intellectual Property Law Association, typical patent litigation costs are estimated to be around $1 million through the discovery stage and $2 million through any appeal process for cases in which the stakes are between $1-25 million. Figure 4 describes a typical case with litigation costs that illustrates the discrepancy between private and social incentives to form ex ante patent pools, with the assumption that litigation costs are about one tenth of the profits the firms can receive as a patent pool member (χ = 0.1). If the stakes in patent litigation are measured by the difference in the expected payoffs between the case in which its own patent is validated and the case in which it is invalidated, they also depend on the probability that the other firm’s patent is validated. Assuming that the other firm’s patent is upheld with probability ½, the figure essentially assumes that the litigation costs are approximately 6.7% of the stake in litigation, which seems to be roughly consistent with the ratio of average litigation costs to stakes in the survey by the American Intellectual Property Law Association.

27 If the stakes in patent litigation are measured by the difference in the expected payoffs between the case in which its own patent is validated and the case in which it is invalidated, they also depend on the probability that the other firm’s patent is validated. Assuming that the other firm’s patent is upheld with probability ½, the figure essentially assumes that the litigation costs are approximately 6.7% of the stake in litigation, which seems to be roughly consistent with the ratio of average litigation costs to stakes in the survey by the American Intellectual Property Law Association.
\[ \tilde{L}_B = \{ (\alpha, \beta) \in [0,1]^2 \mid \beta > \Psi_b(\alpha) = \frac{89}{90(2 - \alpha)} \}, \text{ and patent pools should be allowed only when } \beta \geq 1 - \frac{1}{5(1 - \alpha)} \text{ if } (\alpha, \beta) \in \tilde{L}. \]

Figure 4: Discrepancy between Private and Social Incentives to Litigate ($\Delta \geq V/2$) with Litigation Costs

III.3. Patent Invalidation as a Public Good and Policy Implications

My model suggests that patent-holders cannot be relied on to initiate litigation against each other and weed out patents of suspect value, especially when both of them
have weak patents. The public good nature of patent invalidation may also preclude
third parties’ incentives to weed out patents of suspect value. This occurs because even
if the parties directly involved in the litigation have the same information ex ante, the
outcome of the court decision may reveal information that could have further
ramifications. This is particularly true when there are other interested parties. More
specifically, consider a situation in which there are many potential entrants. In such a
case, when a third party challenges and invalidates a patent the entire cost of litigation is
borne by the challenger, but the benefits of invalidation could accrue to all potential
entrants. This is due to the Supreme Court’s 1971 decision in *Blonder-Tongue* that if a
challenger successfully invalidates a patent, other potential infringers of the patent can
rely on this and need not pay royalties. The free-riding problem created by *Blonder-
Tongue* could limit the incentives for a third party to invalidate weak patents.

Considering the lack of private incentives to challenge each other’s
complementary or competing patents among weak patent-holders through patent pools, it
is an important policy mandate to provide incentives for third parties to challenge weak
patents. This is particularly true considering a recent explosion in the number of
patents granted, perhaps due to the reduced resources available to assess patent
applications. There are several reasons inside the US Patent Office to issue rather than
reject patent applications. First, the backlog of applications in the Patent Office induces a
bias toward making the grant in close cases since rejected cases can come back with

---

29 The third parties’ incentives to challenge patents can be further damaged if patent holders form a patent
pool and include a joint defense agreement because setting up a joint defense fund and filling a war chest
can send a strong signal to discourage any potential challengers. See Gilbert (2002) for examples.
30 One policy to get around the free rider problem may be to enable the Department of Justice or Federal
Trade Commission to challenge weak patents. However, they may suffer an informational or motivational
disadvantage since competitors in the same industry are expected to lose most and have the most intimate
knowledge concerning prior art, especially in new subject matter areas. See Chiou (2006) for an analysis of
how to design post-grant patent challenges to utilize competitor’s information on prior art.
broadened over time in the US to permit patenting of business methods and software. Klemperer (2004)
argues that it has gone too far in the US and recommends against extending protection to business methods
and software in Europe.
amendments to the application that lead to further work. Second, the rejected cases may invite the risk of reversal when they are appealed through the administrative review process (see Areeda 1981, pp. 568-569). Thus, it is of paramount importance to weed out patents of dubious merit through adversarial contests in the court or during the examination process.

In this respect, the Hatch-Waxman Act for the pharmaceutical industry is a case in point. The Act, whose full name is Drug Price Competition and Patent Term Restoration Act of 1984, was enacted to achieve two objectives: (1) increase the ability of generic drug manufacturers to offer consumers lower cost copies of off-patent prescription medicines, and (2) spur the discovery and development of new, innovative pharmaceuticals by research based companies. One of the clauses in the Act provides incentives to contest the validity of a patent by giving successful challengers of the patent an exclusive right to market the generic copy for 180 days. I propose that this type of limited time, exclusive marketing right afforded to the first challenger in the Hatch-Waxman Act to be extended to other industries.

Similar proposals to alleviate the free rider problem have been independently made by other scholars. Thomas (2001), for instance, proposes a mechanism that pays a cash bounty to anyone who provides information that helps defeat a patent application to the Patent Office. Kesan (2002) recommends a one-way fee shifting rule in which the patentee is required to pay all or a part of the challenger’s litigation costs if a patent were to be invalidated in its entirety or partially in order to solve the free-rider problem. Miller (2004) critiques Thomas’ proposal on the ground of the bounty’s timing. Since the

---

33 However, this clause has been abused in the pharmaceutical industry since the exclusivity right was extended to the first company to file a so-called Paragraph IV Abbreviated New Drug Approval, rather than the first firm to win its litigation. This loophole allowed a first filer to collusively agree with the patent-holder not to enter the market and thus not trigger its exclusivity period, thereby foreclosing entry by later filers. To prevent such an abuse, the exclusivity right should be afforded to the first firm to invalidate the patent. See Bulow (2003) for more details. I thank Josh Lerner for this observation.
majority of the patents issued have no commercial value, the mechanism operating at the examination stage may not be worth the cost. Miller further argues that, although Kesan’s proposal improves on that of Thomas in terms of timing, the fee shifting mechanism does not properly reflect the stakes involved in litigation because the litigation costs “vary in a much narrower range than does the amount at stake.” Thus, he proposes a bounty mechanism that awards the successful challenger of a patent with an amount equal to the net profits the patentee has earned up to the date of judgment as a result of practicing the patented technology. Thus, his proposal is similar to mine in that the reward to the successful challenger is commensurate with the market value of the technology at issue.

Another mechanism to eliminate patents of suspect value would be introduction of a European style administrative opposition procedure in the US patent system as an alternative to expensive and time-consuming litigation. The current US patent system under the 1999 Act, in principle, allows adversarial inter partes re-examination of the patent if previously undisclosed and relevant prior art in the form of either a prior patent or publication can be presented. In practice, however, the process continues to be an essentially ex parte relationship between patent applicants and examiners for several reasons. For instance, Farrell and Merges (2004) point out that under the 1999 Act, any issue raised by a challenger during the re-examination procedure cannot be re-contested in a later court trial if the challenger decides to litigate. Unless the challenger has sufficient confidence in the Patent Office’s ability to make the right decision in the re-

---

34 The logic of Miller’s criticism of the Thomas mechanism is similar to the Lemley’s (2001) argument that strengthening the examination process in the Patent Office is not cost effective. Since very few patents have commercial value and are licensed, it would be socially optimal to spend its resources for judicial inquiry of patent validity ex post in a few selective cases that matter, rather than spending more resources on better screening of all patents ex ante. According to Lemley, the Patent Office is “rationally ignorant” in issuing “weak patents” of questionable validity. However, my paper and Farrell and Merges (2004) point out that the litigation system cannot be relied on to weed out weak patents.


36 See Choi (2005) for the details.
examination procedure, it is too great a risk for the challenger to request for inter partes reexamination. As a result, the efficacy of the system has been very limited. The European opposition system, in contrast, allows more involvement of the challengers in the process, and has proven to be much more effective in invalidating weak patents as compared to the US opposition system.

IV. Disputes over Priority and Correlation in the Probability of Validity

Up to now I have assumed that the probability of validity of each patent is independent of any others. This would be an appropriate assumption in the case of complementary patents. If the dispute concerns substitute patents, it would be a reasonable assumption if the technologies of the two disputed patents were developed by taking completely different research approaches. For instance, in the case of EPO used for treating anemia, Genetics Institute had a patent on a method for purifying EPO from natural sources while Amgen had a patent on a process for using recombinant DNA to make EPO (Viscusi, Vernon, and Harrington, 1995). However, in the case of substitute patents, there could be situations in which both patents essentially cover the same product and the dispute is on priority. Then, the validity of these two patents would be correlated since only one firm can prevail in the court. In this section, I consider an extension and check the robustness of the model to changes in the nature of disputes and the possibility of correlation in the probability of patent validity.

To be more precise, consider a situation where two firms, A and B, are involved in a patent dispute. These two firms have conflicting patents for a new product in that the relative priority of their patents is at stake. The discovery process of the patent suit

---

37 According to Hall et al. (2003), there were no inter partes re-examination requests in 2000 and only one in 2001. See also Graham et al. (2002)
38 An empirical study by Graham et al. (2002) shows that on average 35.1% of challenged patents are revoked in Europe whereas only 9.7% of challenged in the US patents are revoked.
39 Disputes over priority are known as patent interferences.
may reveal certain earlier inventions suggesting that these two firms’ claims are not sufficiently novel to satisfy patent law standards of patentability. One possibility of the patent suit, therefore, is that both patents are held invalid. This type of uncertainty in the outcome of a patent suit is captured by a probability $\alpha$ that the disputed patents satisfy the novelty requirement.\textsuperscript{40} For simplicity, let me assume, conditional on these patents satisfying the novelty requirement, that the probability of one firm’s patent having priority over the other is the same across the two firms, with each firm being equally likely to win in the suit. In other words, these two firms have the same probability of $\alpha/2$ that their patents will be upheld if they are contested in court. With the remaining probability of $(1-\alpha)$, both patents are held invalid. These probabilities are assumed to be known and shared by both parties.

To focus on the discrepancy between private and social incentives to litigate, let me assume away any legal costs involved in the litigation process. Then each firm in dispute has the following expected payoff from the patent suit.

\begin{equation}
V_A^L = V_B^L = \frac{\alpha}{2} \Pi^M
\end{equation}

If these two firms choose to coexist, each firm has a duopoly profit of $\Pi^D$ for sure, assuming no further entry:

\begin{equation}
V_A^{NL} = V_B^{NL} = \Pi^D
\end{equation}

Therefore, they will litigate if $\alpha \geq \frac{2\Pi^D}{\Pi^M}$.

Now let us analyze the incentive to litigate from a social planner’s viewpoint. Assume that industry structure becomes perfectly competitive due to free entry when the patents are invalidated. Then, the social welfare resulting from the patent suit is:

\begin{equation}
SW^L = \alpha \, WM + (1-\alpha) \, WC
\end{equation}

The social welfare without litigation is given by:

\textsuperscript{40}See Scotchmer and Green (1990) and Scotchmer (1991) for an economic analysis of the novelty requirement in a model of sequential innovations.
Therefore, litigation is preferred from the social planner’s viewpoint if \( \alpha \leq \frac{W_C - W_M}{W_C - W^M} \).

Notice that when the patents are substitutes and the nature of disputes is relative priority, invalidation of one patent does not imply that the technology is freely available. In fact, invalidation of only one patent leads to a monopoly situation. Thus, it is natural to assume that \( W_C > W^D > W_M \) in this case.

As an example, consider Cournot competition with linear demands and constant marginal costs: \( P = a - Q \) and \( MC = c \), where \( a > c \). It can be easily verified that litigation is privately optimal if \( \alpha \geq 8/9 \), whereas litigation is socially optimal if \( \alpha \leq 20/27 \). Unless \( \alpha \in [20/27, 8/9] \), there is a conflict between the social and private incentives to litigate. In particular, private firms prefer to litigate when the probability of validity is high whereas the social planner prefers litigation when the probability of validity is low.

The example above also demonstrates the inadequacy of the Shapiro rule (2001) proposed for patent settlement once we account for incentives to litigate. It is easy to see that with substitute patents unrestricted negotiation between the two patentees will always lead to a collusive outcome with social welfare loss. Thus, any licensing arrangement involving substitute patents should be subject to restrictions on the contractual terms. Shapiro (2003) recommends a general rule for evaluating proposed patent settlements, which is to require that “the proposed settlement generate at least as much surplus for consumers as they would have enjoyed had the settlement not been reached and the dispute instead been resolved through litigation.”

The rationale for such a rule is that it fully respects intellectual property rights while protecting the interest of consumers.

---

41 Shapiro (2003), p. 393.
To show the non-applicability of the Shaprio Rule when both patents are weak, consider the Cournot competition example above with a linear demand. Let $CS_M$, $CS_C$ denote consumer surplus when the market structures are monopoly (patents satisfy the novelty requirement and one of the firms wins the priority suit) and perfectly competitive (both patents are invalidated):
\[
(25) \quad CS_M = \frac{(a-c)^2}{8}, \quad CS_C = \frac{(a-c)^2}{2}
\]
This implies that the expected consumer surplus from ongoing litigation is
\[
(26) \quad \bar{CS} = \alpha CS_M + (1-\alpha) CS_C
\]
\[
= \frac{4-3\alpha}{8}(a-c)^2
\]
Let $\bar{p}$ denote the price that results from the settlement between the two firms. Then, to maintain the expected consumer surplus from litigation $\bar{CS}$, the maximum settlement price allowed would be
\[
(27) \quad \bar{p} = kc + (1-k)a, \text{ where } k = \sqrt{\frac{4-3\alpha}{4}}\text{  }^{42}
\]
A natural way to implement the outcome would be a cross-licensing arrangement with a per-unit royalty rate. More specifically, with a royalty rate of $r$, each firm’s marginal cost becomes $c + r$. With Cournot competition and the linear demand curve, each firm produces $[a - (c + r)]/3$ and the market price is $[a + 2(c + r)]/3$. Thus, the royalty rate of $r = [1-(3k/2)](a-c)$ will induce the market price of $\bar{p} = kc + (1-k)a$.

The Shapiro rule is certainly a sensible rule once firms are already engaged in patent disputes. The problem is that the rule has no bite when their patents are weak since neither of them will have an incentive to litigate in the first place. Instead, they would prefer to maintain the status quo without challenging each other’s patents. More precisely, if they litigate and the Shapiro rule is enforced for settlement, each firm’s profit

---

42 Let $CS(p)$ be the level of consumer surplus when the market price is $p$. With the linear inverse demand curve of $p = a - Q$, $CS(p) = (a - p)^2/2$. Thus, $\bar{p}$ is defined by $CS(\bar{p}) = \bar{CS}$, which yields the expression in equation (27).
would be \([(1-k)(a-c)]^2\). In contrast, if they adopt the strategy of coexistence without challenging each other, they can secure the duopoly profits of \((a-c)^2/9\). Thus, when \(k>2/3\), or equivalently if \(\alpha < 20/27\), neither firm has an incentive to challenge the other’s patent. As a result, the distortion due to the weak patents will not be corrected through the litigation process.

V. Concluding Remarks

In this paper I have developed a simple model of patent pools that take place in the shadow of patent litigation. I analyzed private incentives to litigate and compared them with the social incentives. Antitrust implications of patent pools were considered.

The analysis of the paper points out, inter alia, the serious lack of private incentives to weed out patents of suspect value through litigation. This is especially troubling in view of the recent explosion of patent awards triggered by U.S. patent reform in the last two decades and escalating litigation costs.\(^{43}\) This development has led some commentators to even question whether the proliferation of patent awards may impede rather than promote innovation (Gallini, 2002). Considering ex parte relationships between patent applicants and examiners, it is important to subject patents of dubious merit to adversarial contests in the court. The current patent system, however, suffers from a free-rider problem.\(^{44}\) To mitigate the problem, it may be necessary to grant limited time, exclusive marketing rights to the first challenger to successfully invalidate patents as in the Hatch-Waxman Act for the pharmaceutical industry. As an alternative mechanism to eliminate patents of suspect value, we may seriously consider adopting a

---

\(^{43}\) See Lerner (1995) for an empirical analysis of patent litigation. He estimates the costs of patent litigation started in 1991 at about $1 billion, which amounts to 27 percent of basic R&D expenditures by US firms in the same year.

\(^{44}\) One referee suggested that a policy to avoid the free rider problem would be to enable the Department of Justice or Federal Trade Commission to challenge weak patents. One drawback with such a policy may be that these agencies would typically have less information about the validity of patents compared to the competitors in the same industry.
European style *administrative opposition* procedure in the US system and/or allowing the participation of third parties through *pre-grant publication* of patent applications.\textsuperscript{45}

I conclude by mentioning a few avenues of research to extend the simple model in this paper. First, I have assumed a symmetric information structure in which all potential litigants have the same beliefs about the validity, scope, and enforceability of the patents considered. This assumption can be suspect if the patentee has better information regarding validity since she may know the potential weaknesses of the patent (Meurer, 1989). Without symmetric beliefs, mutual optimism concerning the outcome of litigation could lead to patent disputes in court. Out-of-court settlement then can be explained by the revelation of a new piece of information that leads to shared beliefs. Consideration of such private information introduces a whole new set of problems and allows much richer dynamics. The mere decision to bring a suit, for instance, can have informational content especially when out-of-court settlement is possible. In addition, if there is private information held by either of the disputing parties regarding the validity of the patent, litigation behavior in court can have signaling value and potentially influence the terms of licensing just as predatory behavior of the incumbent can affect the terms of a merger with the entrant [Saloner (1987), Meurer (1989)]. This is an important agenda for future research.

\textsuperscript{45} See Jaffe and Lerner (2004) and Choi (2005) for more discussion on patent system reform.
References


Lanjouw, Jean O. and Schankerman, Mark, “Enforcing Intellectual Property Rights:
Suits, Settlements and the Explosion in Patent Litigation,” unpublished manuscript, June 2002


