

PATENT POOLS AND CROSS-LICENSING IN THE SHADOW OF PATENT LITIGATION

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Abstract

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. The effects of patent pools on third party incentives to challenge the validity of patents and on development incentives are also investigated.

JEL Classification: O3, L1, L4, D8, K4.

Keywords: patent pools, cross-licensing, complements and substitutes, patent litigation.

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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 maker –NEC, Hitachi, Fujitsu, Oki Electric and Toshiba—and 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 a 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.

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.¹ 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 this risk arises in patent litigation cases is that the alleged infringers invariably make a counterclaim by challenging the validity and enforceability of patents.

¹ 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.

Most of the literature on patent protection assumes ironclad patents and a so-called strict "fencepost" system in which 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.² 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.³ 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.⁴ 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.⁵

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.⁶ 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 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

²Notable exceptions are Meurer (1989), Waterson (1990) and Choi (1998).

³ 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.

⁴ See also Green and Scotchmer (1995) and O'Donoghue, Scotchmer and Thisse (1998).

⁵ To illustrate the importance of court decisions on patent validity in infringement suits, I point out that of the 294 patents contested in all federal appellate courts between 1966 and 1971, only 89 (about 30 %) were found to be valid (Kintner and Lahr, 1975).

⁶According 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."

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.⁷

This paper develops a model of patent pools/cross-licensing in which the incentives to litigate are explicitly taken into account.⁸ 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. The effects of patent pools on third party incentives to challenge the validity of patents and on development incentives are also investigated.

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.”⁹ 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

⁷ See Areeda (1981) for a detailed account of the industry history.

⁸ See Lanjouw and Schankerman (2001) for an empirical analysis of patent litigation.

⁹ Shapiro (2003), p. 393.

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.

Lerner and Tirole (2002) 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.¹⁰ However, litigation incentives are tangential to their analysis. My paper and Lerner and Tirole (2002) focus on different aspects of patent pools and thus should be viewed as complementary.

Finally, Gilbert (2002) 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 of the patents involved. In his review of the legal case, however, he finds that the most decisive factor in courts’ determination of whether patent pools have violated the antitrust laws has been restrictive licensing terms. Gilbert (2002) 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.

¹⁰ 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.

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 complementary patents that takes place in the shadow of litigation. Section III extends the analysis to patent pools with substitute patents. The basic presumption in the literature to date and enunciated in the *Antitrust Guide Lines for the Licensing and 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. Concluding remarks follow in section IV.

II. The Model with Complementary Patents

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. This section considers the case where the two patents are complementary whereas an analysis of substitute patents is provided in the next section. More specifically, I consider a situation in which commercialization of a new technology or product requires the use of multiple patents. This would be the case if the two patents were blocking each other in the sense that the practice of each patent infringes on the other in the absence of a license.¹¹ I assume that patent holders are not participants in downstream competition, and thus their source of income is royalties from licensing. This would be the case if the intellectual property to be licensed is a research tool (Schankerman and Scotchmer, 2001). In this scenario, any producers

¹¹ In this case, the two patents are said to be in a two-way blocking relationship. They are in a one-way blocking relationship if the practice of one patent requires a license from the other, but the practice of the latter does not require a license from the former. This type of situation typically arises when the former is an improvement of the latter. See Gilbert (2002) for more details.

of the product need to get licenses from both patentees. I analyze incentives to form a patent pool by the patent owners and the competitive implications of package licensing.¹²

The innovation in this paper is that I treat the intellectual property rights associated with the patents as probabilistic in the analysis of patent pools. In legal parlance, I assume a "signpost" system of patents and explicitly consider the uncertainty in the extent of protection a patent provides in the analysis of the incentives to form a patent pool.¹³ The uncertainty about the validity of the patents is represented by the parameters α and $\beta \in [0,1]$, which are the probabilities that the court will uphold the validity of patents A and B, respectively, if there are challenged. I assume a symmetric information structure in that α and β are common knowledge.

II. 1. Patent Pools in the Absence of Patent Disputes

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. I assume that there are many potential licensees with a constant unit production cost of c at the downstream stage, and the licensing is non-exclusive.¹⁴ With price competition, the equilibrium price of the product becomes $c + r_A + r_B$, given the royalty rates of r_A and r_B .

Let $Q(P)$ be the demand function for the product covered by the patents. I assume that $Q(\cdot)$ is a decreasing and twice continuously differentiable function, with $Q'(P) + PQ''(P)$

¹² The analysis will also apply to a situation where the two patent owners are engaged in downstream competition. In such a case, the collaborative arrangement between the two patent owners would be cross-licensing arrangements.

¹³ In the "fencepost" interpretation of patent specifications, the perimeter of the patentee's claims is assumed to be clearly marked out. The "signpost" interpretation regards the patent specification as merely pointing the reader in the direction which he may not travel without a license.

¹⁴ In fact, exclusive licensing is not optimal with a per-unit royalty due to double marginalization unless there are significant fixed costs associated with the downstream production.

< 0 . Without loss of generality, let us assume that the production costs of downstream firms are zero. Then firm A solves the following problem given firm B's royalty rate r_B .

$$(1) \quad \underset{r_A}{\text{Max}} \quad r_A \cdot Q(r_A + r_B).$$

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

$$(2) \quad Q(r_A + r_B) + r_A \cdot Q'(r_A + r_B) = 0,$$

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 Nash equilibrium royalty rates r_A^* and r_B^* are at the intersection of these two reaction functions. The stability and the uniqueness of the Nash equilibrium in the royalty rates are ensured with the assumption $Q'(P) + PQ''(P) < 0$. The total royalty rate is given by $R^* = r_A^* + r_B^*$.

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

$$(3) \quad \underset{R}{\text{Max}} \quad R \cdot Q(R)$$

Let \tilde{R}^* be the optimal royalty rate for the pool.¹⁵ Then, \tilde{R}^* satisfies the following first order condition:

$$(4) \quad Q(\tilde{R}^*) + \tilde{R}^* \cdot Q'(\tilde{R}^*) = 0$$

Proposition 1 shows that the overall royalty rate for the licensees is lower with the formation of patent pools. Thus, patent pools are procompetitive with complementary patents.

Proposition 1. $R^* = r_A^* + r_B^* > \tilde{R}^*$. Since the total royalty rate decreases with the formation of the patent pool, social incentives and private incentives to form a patent pool are completely aligned.

Proof. The Nash equilibrium royalty rates r_A^* and r_B^* satisfy

¹⁵ Variables associated with patent pools are denoted with a tilde.

$$2Q(r_A^* + r_B^*) + (r_A^* + r_B^*) \cdot Q'(r_A^* + r_B^*) = 0$$

Let me evaluate the first order condition for the patent pool (4) at $R^* = r_A^* + r_B^*$. Then,

I have

$$Q(r_A^* + r_B^*) + (r_A^* + r_B^*) \cdot Q'(r_A^* + r_B^*) = -Q(r_A^* + r_B^*) < 0$$

This implies the desired result that $R^* = r_A^* + r_B^* > \tilde{R}^*$. *Q.E.D.*

This is a well-known result that dates back to Cournot's (1927) analysis of the complementary monopoly problem. 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. Thus 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 the patent protection is not perfect. In such a case, I show that more caution is needed in granting blanket immunity towards patent pools comprised of complementary patents, especially when weak patents are involved.

II. 2. Patent Pools in the Presence of Patent Disputes

To investigate implications of the "signpost" system of patents, I now consider the possibility that the scope of 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 complementary 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 litigation; the counter-suit does not add significantly 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.

Let Π^M and Π^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 complementary patents. That is, $\Pi^M = \tilde{R}^* \cdot Q(\tilde{R}^*)$ and $\Pi^D = r^* \cdot Q(2r^*)$, where $\Pi^M > 2\Pi^D$. Let the legal costs of litigation be denoted by χ , which are assumed to be the same for both firms.

Each firm's profits without litigation are given by:

$$V_A^{NL} = V_B^{NL} = \Pi^D$$

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

$$V_A^L = \alpha [\beta \Pi^D + (1-\beta) \Pi^M] - \chi, \quad V_B^L = \beta [\alpha \Pi^D + (1-\alpha) \Pi^M] - \chi$$

Firm A will have an incentive to litigate if

$$(5) \quad \Lambda_A = V_A^L - V_A^{NL} = \{\alpha [\beta \Pi^D + (1-\beta) \Pi^M] - \chi\} - \Pi^D \geq 0$$

For firm A, the incentive to litigate is increasing in the strength of its own patent, α , and decreasing in the strength of the complementary patent, β . Thus, given the other firm's patent strength β , firm A will litigate if

$$(6) \quad \alpha \geq \psi_A(\beta) = \frac{\Pi^D + \chi}{\beta \Pi^D + (1-\beta) \Pi^M}$$

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

Similarly, firm B will have incentive to litigate if

$$(7) \quad \Lambda_B = V_B^L - V_B^{NL} = \{\beta [\alpha \Pi^D + (1-\alpha) \Pi^M] - \chi\} - \Pi^D \geq 0$$

That is, given the strength of firm A's patent, α , firm B will initiate litigation if

$$(8) \quad \beta > \psi_B(\alpha) = \frac{\Pi^D + \chi}{\alpha \Pi^D + (1-\alpha) \Pi^M}$$

Let \mathbf{L}_A and \mathbf{L}_B denote the set of (α, β) that satisfies conditions (5) and (7), respectively, i.e.,

$$(9) \quad \mathbf{L}_A = \{(\alpha, \beta) \in [0,1]^2 \mid \alpha [\beta \Pi^D + (1-\beta) \Pi^M] - \chi > \Pi^D\}$$

$$\mathbf{L}_B = \{(\alpha, \beta) \in [0,1]^2 \mid \beta [\alpha \Pi^D + (1-\alpha) \Pi^M] - \chi > \Pi^D\}$$

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

The analysis above 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 the royalty income is divided between the two firms. I assume that the surplus from negotiation is equally split between the two firms. When the parameters (α, β) belong to the set \mathbf{NL} , that is, both firms have no incentive to litigate, both will get the same royalty rate $\tilde{R}^*/2$ regardless of their relative patent strengths. When $(\alpha, \beta) \in \mathbf{L}$, there will be litigation without a patent pool. In this case, the division of the royalty income reflects the relative strength of the patents. Let κ and $(1-\kappa)$ denote the proportions of the royalty income that accrue to firm A and B, respectively. Then, the Nash bargaining solution with equal surplus implies that

$$(10) \quad \kappa \Pi^M - \alpha [\beta \Pi^D + (1-\beta) \Pi^M] - \chi = (1-\kappa) \Pi^M - \beta [\alpha \Pi^D + (1-\alpha) \Pi^M] - \chi.$$

This yields $\kappa = \frac{1 + \alpha - \beta}{2}$.

Proposition 2. Under Nash bargaining, the royalty rates are the same for both firms at $R^*/2$ when both firms have weak patents, that is, $(\alpha, \beta) \in \mathbf{NL}$. If $(\alpha, \beta) \in \mathbf{L}$ and at least one of the firms has incentives to litigate, the royalty rates reflect the relative strength of the patents in the pool.

Example. Consider a case where the downstream market demand is given by a linear demand $Q(P) = a - P$. In this case, the profits for the monopoly and duopoly are given by $\Pi^M = \frac{a^2}{4}$ and $\Pi^D = \frac{a^2}{9}$, respectively. For simplicity, assume that the cost of litigation is negligible, that is, $\chi = 0$. 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 α 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 1, the value of patents can be discontinuous in patent strength at the point of regime change.

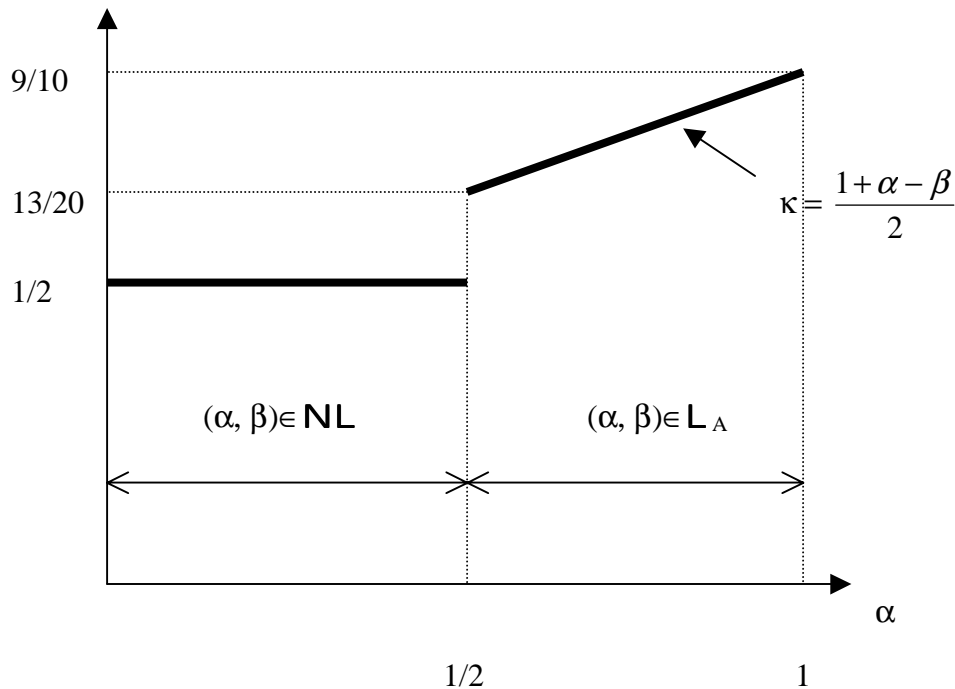


Figure 1: Firm A's Share of Royalty Income as a function of α with $\beta = 1/5$

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. Thus, 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.

II. 3. Social Incentives to Form Patent Pools

Let $CS(P)$ be the level of consumer surplus when the downstream market price is given by P , where $CS'(P) < 0$. 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, the market price at the downstream stage becomes zero. Instead, if both patents are deemed valid, the price 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 have the same objective function as the patent pool and charges \tilde{R}^* that maximizes Eq. (3).

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.

$$W^M = \Pi^M + CS(\tilde{R}^*), \quad W^D = 2 \Pi^D + CS(R^*), \quad W^C = CS(0)$$

With complementary patents, we have $W^D < W^M < W^C$.

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

$$\begin{aligned}
SW^L &= [\alpha \beta W^D + (\alpha - 2\alpha\beta + \beta)W^M + (1 - \alpha)(1 - \beta)W^C] - 2\chi \\
&= \alpha \beta [2 \Pi^D + CS(R^*)] + (\alpha - 2\alpha\beta + \beta) [\Pi^M + CS(R^*)] + (1 - \alpha)(1 - \beta)[CS(0)] - 2\chi
\end{aligned}$$

If there is no litigation and no patent pool, the market price at the downstream stage is $R^* = r_A^* + r_B^*$. Thus, social welfare without litigation is given by

$$SW^{NL} = W^D = 2 \Pi^D + CS(R^*)$$

I now consider the optimal antitrust policy concerning patent pools in a situation where the social planner's only decision is to approve patent pools or not. To analyze the social incentives to form patent pools, I need to consider two cases.

Case 1. $(\alpha, \beta) \in L$

In this case, if the patent pool is not allowed there will be patent litigation challenging the validity of each other's patent. Thus, patent pools should be allowed if

$$\begin{aligned}
\tilde{W} - SW^L &= W^M - [\alpha \beta W^D + (\alpha - 2\alpha\beta + \beta)W^M + (1 - \alpha)(1 - \beta)W^C] - 2\chi \\
&= (1 - \alpha)(1 - \beta)[W^C - W^M] - \alpha \beta [W^M - W^D] - 2\chi \geq 0
\end{aligned}$$

If the litigation cost is negligible, this condition can be rewritten as:

$$\beta \geq \frac{(1 - \alpha)[W^C - W^M]}{\alpha[W^M - W^D] + (1 - \alpha)[W^C - W^M]} = \frac{(1 - \alpha)}{\alpha\Omega + (1 - \alpha)}$$

where $\Omega = \frac{W^M - W^D}{W^C - W^M}$.

To be more concrete, let me consider a specific case where the downstream market demand is given by a liner demand $Q(P) = a - P$. In this case, firms A and B will set the royalty rate of $r_A^* = r_B^* = a/3$, whereas the optimal royalty rate under a patent pool or monopoly is $\tilde{R}^* = a/2$. The profits for the monopoly and duopoly are given by $\Pi^M = \frac{a^2}{4}$ and $\Pi^D = \frac{a^2}{9}$, respectively. I can also derive consumer surplus associated with each market structure:

$$CS^M = CS\left(\frac{a}{2}\right) = \frac{a^2}{8}, CS^D = CS\left(\frac{2a}{3}\right) = \frac{a^2}{18}, CS^C = CS(0) = \frac{a^2}{2}$$

Then,

$$W^M = CS^M + \Pi^M = \frac{3a^2}{8}, W^D = CS^D + 2\Pi^D = \frac{5a^2}{18}, W^C = CS^C = \frac{a^2}{2}$$

$$\Omega = \frac{W^M - W^D}{W^C - W^M} = \frac{7}{9}$$

Thus, patent pools should be allowed only when $\beta \geq \frac{1-\alpha}{1-\frac{2}{9}\alpha}$ if $(\alpha, \beta) \in \mathbf{L}$. The areas of

incongruence between the social and private incentives are represented in Figure 2.

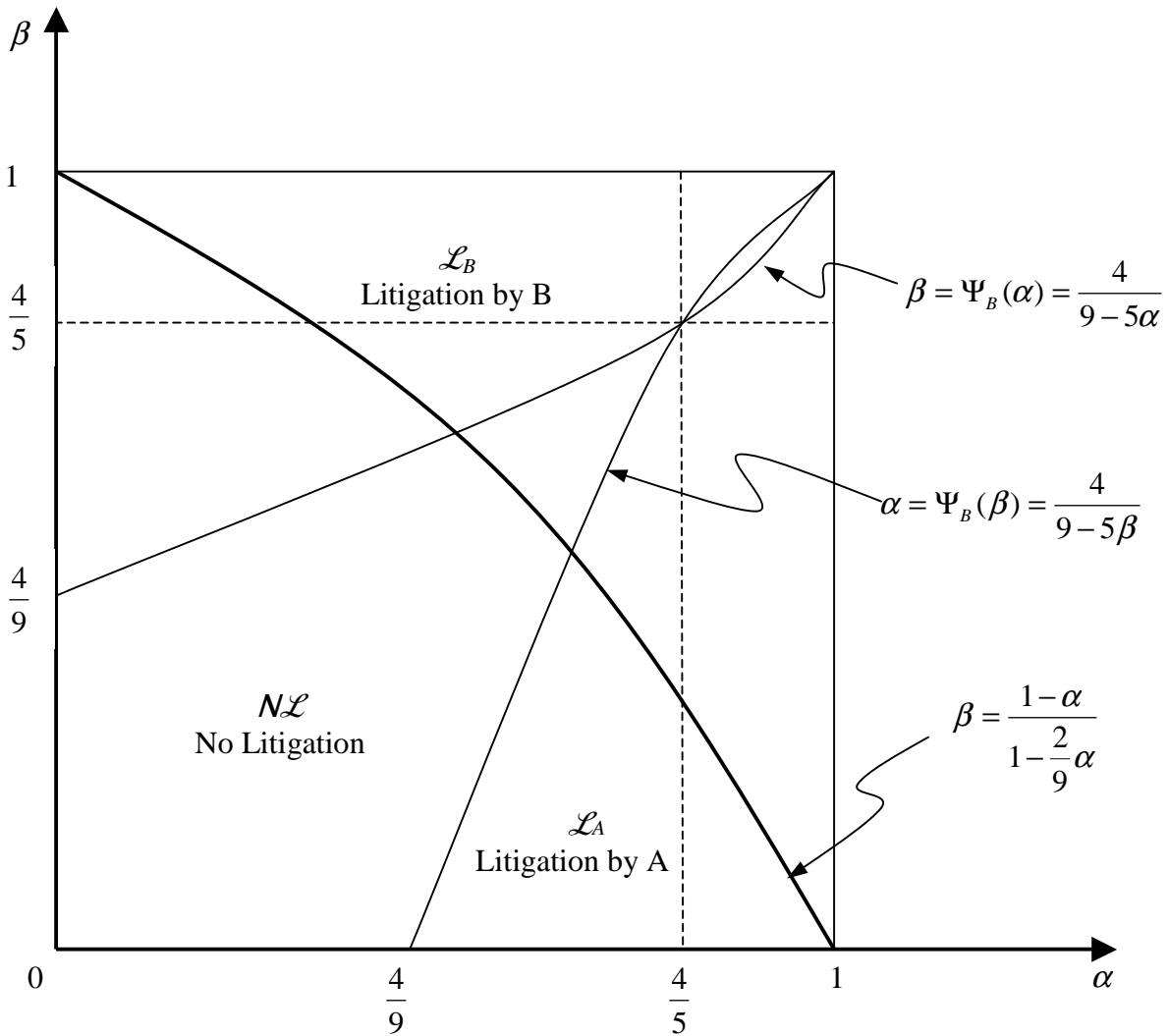


Figure 2: Discrepancy between the Private and Social Incentives to Litigate

Case 2. $(\alpha, \beta) \in \mathbf{NL}$

In this case, if the patent pool is not allowed, there will be no patent litigation. Thus, the social welfare without a patent pool is given by $SW^{NL} = W^D = 2\Pi^D + CS(R^*)$.

This implies that patent pools should be always allowed in this case since

$$\tilde{S}\tilde{W} - SW^{NL} = W^M - W^D > 0$$

Thus, we have a paradoxical result that patent pools should be allowed and the monopoly be preserved exactly when the patents are most suspect and have little value. The reason is that unless there is a third party that has stakes in the invalidation of patents the alternative is 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.

II.4. 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 costs of litigation are borne by the challenger, but the benefits of invalidation could accrue to all potential entrants. This free-riding problem 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.¹⁶ Thus, it is of paramount importance to weed out patents of dubious merit through adversarial contests in the court.

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 rights afforded to the first challenger in the Hatch-Waxman Act to be extended to other industries.

II.5. Third Party Challenge and Joint Defense

Patent pools often include an agreement to jointly defend challenges to patent scope and validity (Gilbert, 2002).¹⁷ In this section, I investigate a mechanism in which a joint defense agreement is used to reduce the probability that patents in the pool will be challenged. To accommodate the possibility of challenge from non patent-holders, let me assume that there is a third party who is interested in invalidating the patents in question. This third party could be a potential entrant to the market or a large consumer who has a stake in the invalidation of the patents. Let me assume that the cost of litigation for each patent is given by χ .

¹⁶ See Gallini (2002) for a discussion of recent U.S. patent reform.

¹⁷ For instance, Mason City Tent and Awning Co. has set up a joint defense fund in a patent pool that covers cab enclosure devices for tractors. Another example is the Krasnov case which also included a joint defense fund in a patent pool for ready-made furniture slip covers. See Gilbert (2002) for more details.

Suppose that there is no joint defense clause in the patent pool and each patent is defended by two separate firms. Without loss of generality, assume that $\alpha > \beta$, that is, patent A is stronger than patent B. For the third party, the litigation would be successful only when it succeeds in invalidating both patents. Let me denote the benefits from invalidating both patents as V . This implies that the optimal litigation strategy for the third party is to litigate them sequentially unless there are any economies of scope in simultaneous litigation. The reason is that sequential litigation provides an option value of saving litigation costs in case the third party fails in invalidating the first patent. To see this, the expected value of simultaneous litigation is given by $(1-\alpha)(1-\beta)V - 2\chi$. If the third party litigates A first, it will litigate B later only when it succeeds in invalidating patent A. Thus, its expected payoff is given by $-\chi + (1-\alpha)[(1-\beta)V - \chi] = (1-\alpha)(1-\beta)V - (2-\alpha)\chi$. Similarly, if the third party challenges patent B first, its expected payoff from litigation is given by $(1-\alpha)(1-\beta)V - (2-\beta)\chi$. A comparison of these three payoffs yields the following proposition.

Proposition 3. In the absence of joint defense of patents, the optimal strategy for third party litigation is to challenge the stronger patent first and if it succeeds in invalidating the first patent, challenge the second one. It implies that the weaker patent hides behind the wall of the stronger patent.¹⁸

The intuition for Proposition 3 can be explained by the option value of sequential litigation. The challenger will continue to litigate the second patent only when it succeeds in invalidating the first patent. By sequentially litigating, it can save the legal

¹⁸ This conclusion ignores the time dimension involved in litigation. If a quick resolution of patent disputes is important, the challenger may decide to challenge patents simultaneously. However, if the legal costs are positively associated with the length of court battle, the cost saving associated with sequential litigation may be more important with protracted litigation, which mitigates the incentive to litigate simultaneously.

cost of challenging the second patent in case it fails in the first try. This option value is proportional to the strength of the patent challenged first, which explains the reason for challenging the stronger patent first.

I assume that with the joint defense agreement in the pool, a third party needs to challenge the pooled patents simultaneously. Let me assume that there is no cost advantage from challenging the pooled patents simultaneously by assuming that the cost of litigation is 2χ . Thus, the joint defense deprives the third party of the option value from sequential litigation with the expected value of litigation being $(1-\alpha)(1-\beta)V - 2\chi$. Thus, we can imagine a situation in which the third party has incentives to litigate without a joint defense agreement but decides not to challenge with joint defense.

$$\frac{(1-\alpha)(1-\beta)V}{2} < \chi < \frac{(1-\alpha)(1-\beta)V}{2-\alpha}$$

To the best of my knowledge, Gilbert (2002) is the only other paper that analyzes a joint defense agreement as a way to strengthen intellectual property rights. In his analysis, he assumes that cooperation changes the probability that each patent would be found valid to the average of the probabilities for both patents, that is, each patent is valid with the probability of $(\alpha+\beta)/2$, if they are contested in the court. With this *ad hoc* assumption, he concludes that a joint defense agreement among patentees is profit-maximizing only if the patents are substitutes. Allowing for a sequential litigation strategy uncovers another channel through which a joint defense agreement discourages the incentives for the third party to litigate.

II.6. Patent Pools and Future Development Incentives

As emphasized by Scotchmer (1991), innovations are cumulative. In order to analyze how the formation of patent pools can affect future incentives to develop new innovations that build on existing patents, I consider the following two-stage game.

Initially, there are two firms A and B that have complementary patents. In the first stage, these two firms decide to form a patent pool. In the second stage, another firm, C, comes with an innovation idea that costs c to develop.¹⁹ The new innovation by firm C can bring additional surplus of Δ to the coalition. The new innovation is assumed to be an improvement on the prior patents that cannot be practiced without consent of the holders of the prior patents. I assume that the parties engage in efficient *ex post* negotiations as in Segal and Whinston (2000) and Gilbert and Shapiro (1997). I abstract from the interim benefit from price coordination of the patent pool in this framework. The only role of patent pool is to change the *ex post* bargaining game from three-party bargaining among firms A, B and C into two-party bargaining between the patent pool and firm C.

As an *ex post* bargaining solution, I adopt Shapley value.²⁰ This implies that once innovation is made by firm C, the surplus Δ will be split equally as an outcome of cooperative bargaining if there were no patent pool in place between A and B such that each firm gets $\Delta/3$. In contrast, if there were a patent pool, the surplus will be equally split between the patent pool and firm C. Thus, each member of the patent pool, A and B, will get $\Delta/4$, whereas the innovating firm C will get $\Delta/2$. Let me assume that the development cost c is randomly distributed with a cumulative distribution function $G(\cdot)$. Then the future innovation will be developed with a probability of $G(\Delta/2)$ with the patent pool and with a probability of $G(\Delta/3)$ without the patent pool. Thus, the patent pool can be considered as a commitment not to extract future surplus and promotes future innovations. The tradeoff in the decision to form a patent pool is between a higher probability of new innovation and less ability to extract surplus from the new innovation.

¹⁹ In contrast, Lerner and Tirole (2002) analyzes the incentives to develop future innovations by patent pool members, not by outsiders.

²⁰ More generally, I can assume a linear bargaining solution as in Segal and Whinston (2000). The Shapley value can be considered as a special case of the linear bargaining solution in which the property of symmetry is imposed.

With the patent pool, firms A and B each get extra surplus of $G(\frac{\Delta}{2}) \cdot \frac{\Delta}{4}$, whereas they get $G(\frac{\Delta}{3}) \cdot \frac{\Delta}{3}$ without the patent pool. Therefore, the patent pool will be formed if

$$G(\frac{\Delta}{2}) \cdot \frac{\Delta}{4} > G(\frac{\Delta}{3}) \cdot \frac{\Delta}{3}$$

With efficient ex post bargaining, the only efficiency loss is from ex ante investment decisions of firm C as in Hart and Moore (1990). From the perspective of a social planner, the efficient investment decision for firm C is to develop the new innovation if and only if $\Delta > c$. Due to rent extraction by the holders of prior patents, there will be less incentive to develop new innovations compared to the social optimum. Patent pools mitigate this problem. I can conclude that due to positive externalities on firm C the private incentives to form patent pools are less than the social incentives. However, I can show that if the number of firms holding complementary patents is very large, there will always be a patent pool, and the social and private incentives converge.

Proposition 4. The private incentive to form patent pools is less than the social incentive. However, as the number of complementary patents increases, the private and social incentives converge.

Proof. Let N be the number of patents owned by N different firms. With N firms, the expected benefit from a patent pool is given by $G(\frac{\Delta}{2}) \cdot \frac{\Delta}{2N}$. Without a patent pool, the

corresponding value is $G(\frac{\Delta}{N+1}) \cdot \frac{\Delta}{N+1}$.

$$\lim_{N \rightarrow \infty} \frac{G(\frac{\Delta}{2}) \frac{\Delta}{2N}}{G(\frac{\Delta}{N+1}) \frac{\Delta}{N+1}} = \frac{1}{2} \lim_{N \rightarrow \infty} \frac{G(\frac{\Delta}{2})}{G(\frac{\Delta}{N+1})} \rightarrow \infty, \text{ which implies that there would be a}$$

patent pool if the number of firms holding complementary patents is sufficiently large.

III. The Model with Substitute Patents

Consider a continuum of product space indexed by $i \in [0, 1]$. To operationalize the notion of patent scope, I assume that the location of a patent can also be represented as a point in the product space. A patent of scope s covers any products that are within the distance of s . I assume that two patents A and B are located at the two extreme points of the product space with A being located at point zero and B at point one. Let s_A and s_B be the scopes of patents A and B, respectively. If $s_A + s_B < 1$, the scopes of the two patents do not overlap. Firm A is the monopolistic supplier of any products located between $[0, s_A]$, and firm B is the monopolistic supplier of any products located between $[1 - s_B, 1]$. Products located between $(s_A, 1 - s_B)$ are supplied competitively. In this case, there is no issue of infringement between the two patents.

If $s_A + s_B > 1$, the scopes of the two patents overlap. Firm A is the monopolistic supplier of any products located between $[0, 1 - s_B]$ whereas firm B is the monopolistic supplier of any products located between $[s_A, 1]$. However, products located between $(1 - s_B, s_A)$ are covered by both patents (see Figure 3). The model potentially encompasses several cases involving the two patents A and B. When $s_A + s_B < 1$, we can consider the two patents as independent. When $s_A + s_B > 1$, the two patents can be considered partially infringing each other, which can lead to patent disputes. The area of overlap, $s_A + s_B - 1$, can be considered as a measure of substitutability of the two patents.

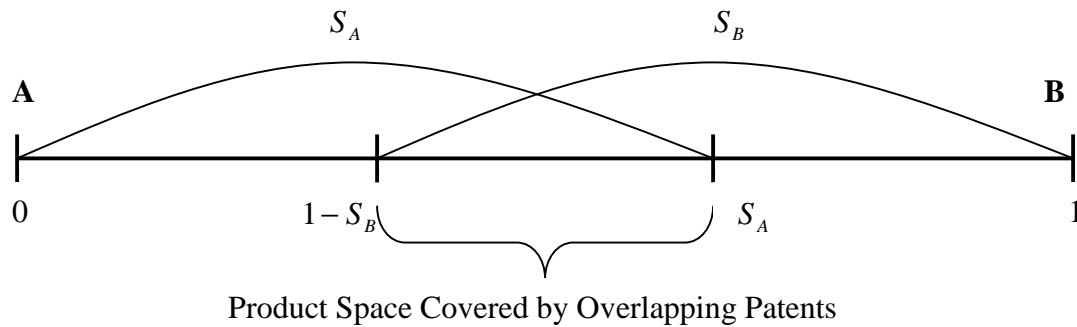


Figure 3. Overlapping Patent Scopes

III.1. Competition and Litigation Incentives without Patent Pools

Let me assume that each product market is symmetric. The monopoly profit in each market is Π^M , and the duopolistic profit is given by Π^D . Since a monopoly is at least as profitable as a joint duopoly, I assume that $\Pi^M \geq 2 \Pi^D$ [Gilbert and Newbery (1982)]. To make the analysis of litigation meaningful, I consider only the case of an overlapping product space that is covered by both competing patents, i.e., $s_A + s_B > 1$. In this case, each firm's profits without any litigation or patent pool are given by:

$$V_A^{NL} = (1-s_B) \Pi^M + (s_A + s_B - 1) \Pi^D, \quad V_B^{NL} = (1-s_A) \Pi^M + (s_A + s_B - 1) \Pi^D$$

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

$$V_A^L = \alpha \beta [(1-s_B) \Pi^M + (s_A + s_B - 1) \Pi^D] + \alpha (1-\beta) s_A \Pi^M$$

$$V_B^L = \alpha \beta [(1-s_A) \Pi^M + (s_A + s_B - 1) \Pi^D] + (1-\alpha) \beta s_B \Pi^M$$

Firm A's incentive to litigate is given by:

$$\Lambda_A = V_A^L - V_A^{NL} = \alpha (1-\beta) s_A \Pi^M - (1-\alpha\beta) [(1-s_B) \Pi^M + (s_A + s_B - 1) \Pi^D]$$

It can be easily verified that

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

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

$$\frac{\partial \Lambda_A}{\partial s_B} = (1-\alpha\beta) (\Pi^M - \Pi^D) > 0,$$

that is, 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. The incentives to litigate also increase with the scope of the other firm's patent. However, the effects of its own patent's scope on the incentives to litigate are ambiguous since $\frac{\partial \Lambda_A}{\partial s_A} = \alpha (1-\beta) \Pi^M$

$- (1-\alpha\beta) \Pi^D$ cannot be signed. Firm B's incentives to litigate can be analyzed in a similar way. There will be litigation if either $\Lambda_A \geq 0$ or $\Lambda_B \geq 0$.

The expected social welfare associated with litigation can be written as:

$$SW^L = \alpha \beta [(s_A + s_B - 1) W^D + (2 - s_A - s_B) W^M] \\ + \alpha (1 - \beta) [s_A W^M + (1 - s_A) W^C] + \beta (1 - \alpha) [s_B W^M + (1 - s_B) W^C] + (1 - \alpha)(1 - \beta)W^C,$$

where W^M , W^D and W^C are once again the welfare levels in each market when the market structures are monopoly, duopoly, and perfectly competitive, respectively. With substitute patents, it is natural to assume that $W^C > W^D > W^M$.

In contrast, social welfare without litigation can be written as:

$$SW^{NL} = (s_A + s_B - 1) W^D + (2 - s_A - s_B) W^M$$

Thus, the social incentive to litigate is given by

$$\Lambda_S = SW^L - SW^{NL} = \alpha (1 - \beta) [s_A W^M + (1 - s_A) W^C] + \beta (1 - \alpha) [s_B W^M + (1 - s_B) W^C] \\ + (1 - \alpha)(1 - \beta)W^C - (1 - \alpha\beta) [(s_A + s_B - 1) W^D + (2 - s_A - s_B) W^M]$$

It is not expected that private incentives to litigate would coincide with social incentives.

In particular, when both patents are weak the private and social incentives will always diverge since $\lim_{\substack{\alpha \rightarrow 0 \\ \beta \rightarrow 0}} \Lambda_S = W^C - [(s_A + s_B - 1) W^D + (2 - s_A - s_B) W^M] > 0$ whereas

$$\lim_{\substack{\alpha \rightarrow 0 \\ \beta \rightarrow 0}} \Lambda_A = - [(1 - s_B) \Pi^M + (s_A + s_B - 1) \Pi^D] < 0 \text{ and } \lim_{\substack{\alpha \rightarrow 0 \\ \beta \rightarrow 0}} \Lambda_B = - [(1 - s_A) \Pi^M$$

$$+ (s_A + s_B - 1) \Pi^D] < 0.$$

To investigate further the divergence of the private and social incentives, let me simplify the analysis by considering the symmetric case in which $\alpha = \beta$ and $s_A = s_B = s > 1/2$. I consider two simple models of competition to make the point.

Bertrand Competition

Let me assume that the demand curve is the same in each market and is given by $Q_i(P_i) = a - P_i$, for all $i \in [0, 1]$. I assume that the two firms compete in price if both produce in the same market with a constant marginal cost of c , where $a > c$. The product is assumed to be homogeneous in each market. Thus, if both firms compete in the same

market, the market outcome is the same as in a perfectly competitive market; each firm's profit is zero and the social surplus is given by $\frac{(a-c)^2}{2}$ in that market. Thus, I have

$$\Pi^M = \frac{(a-c)^2}{4}, \Pi^D = 0, W^M = \frac{3(a-c)^2}{8}, W^D = W^C = \frac{(a-c)^2}{2}.$$

In this case, it can be easily verified that the social incentive to litigate is given by $\alpha > \lambda(s) = \frac{1-s}{2s-1}$, where $\lambda(s)$ is increasing in patent scope s . In contrast, the private

incentive to litigate is given by $\alpha < \lambda(s) = \frac{1-s}{2s-1}$. Thus, with Bertrand competition, the

social and private incentives are *completely opposite* each other.

Cournot Competition

With Cournot competition, each firm's profit under monopoly and duopoly market structures are given by $\Pi^M = \frac{(a-c)^2}{4}$ and $\Pi^D = \frac{(a-c)^2}{9}$. We can also derive

consumer surplus associated with each market structure:

$$CS^M = \frac{(a-c)^2}{8}, CS^D = \frac{2(a-c)^2}{9}$$

Then,

$$W^M = CS^M + \Pi^M = \frac{3(a-c)^2}{8}$$

$$W^D = CS^D + 2\Pi^D = \frac{4(a-c)^2}{9}$$

$$W^C = CS^C = \frac{(a-c)^2}{2}$$

It can be verified that there should be litigation if $\alpha < \lambda(s) = \frac{1-\frac{5}{7}s}{2s-1}$, but there would be

no litigation for any values of α and s . Thus, unless the patents are very strong (i.e., $\alpha >$

$\frac{1-\frac{5}{7}s}{2s-1}$), there would be divergence in the social and private incentives (the shaded area

in Figure 4).

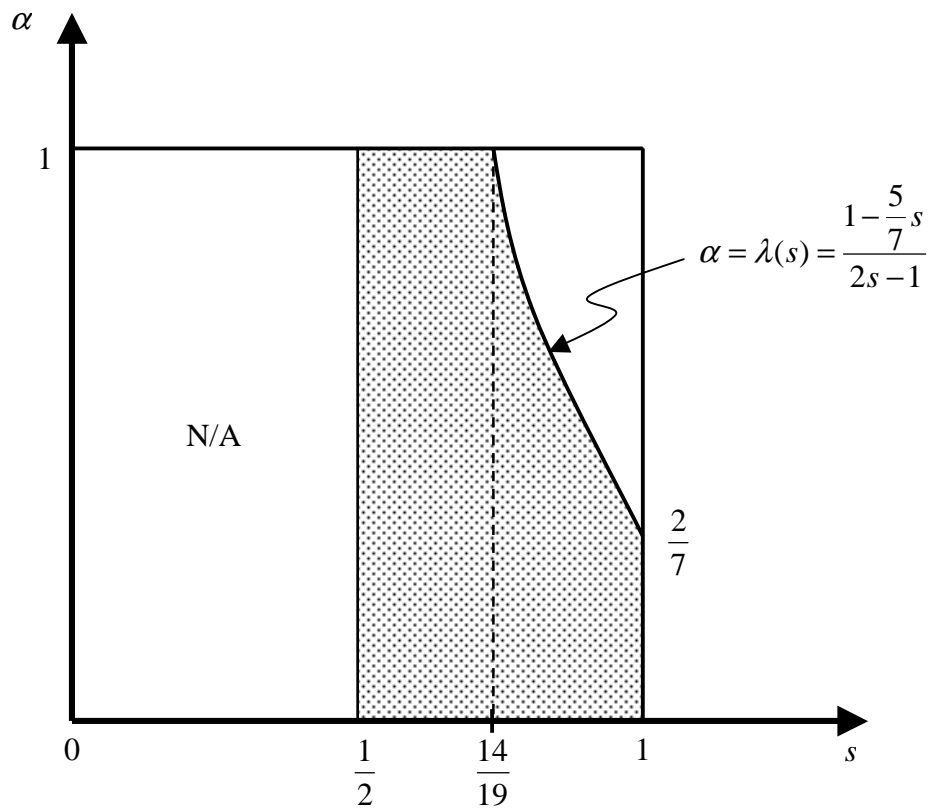


Figure 4. Divergence in the Private and Social Incentives to Litigate

III.2. Competitive Effects of Royalty-Free Cross-Licensing

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. I will demonstrate that even royalty-free cross-licensing agreements could be harmful especially when the two patents are weak and the extent to which the scopes of two patents overlap is significant.

To illustrate the point, consider the case where the two patents cover the same product range and thus $s=1$. To fix the idea, 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 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 α that the disputed patents satisfy the novelty requirement.²¹ 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.

In this situation, there are three possible scenarios to consider: (1) Both patents are invalidated. In this case, there is no patent any longer, and I assume that there will be free entry until each firm's profit is driven down to zero. For the patentees, the existence of multiple potential entrants implies that the infringement suit is a risky business to conduct. If the disputed patents are invalidated in the suit, further entry into the industry will be facilitated. (2) One of the patents is upheld while the other is invalidated. In this case, the industry structure becomes a monopoly. A recent example of EPO, used for treating anemia, is a case in point. In this case, Genetics Institute had a patent on a method for purifying EPO from natural sources, and Amgen had a patent on a process of using recombinant DNA to make EPO. The court upheld the patent of Amgen (Viscusi, Vernon, and Harrington, 1995). (3) These two firms can make an out-of-court settlement. In this case, I assume that these two firms cross-license their patents, and as a result, the industry is duopolistic.

²¹See Scotchmer and Green (1990) and Scotchmer (1991) for an economic analysis of novelty requirement in a model of sequential innovations.

To focus on the information revelation aspect of patent suits, 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.

$$(11) \quad V_A^L = V_B^L = \frac{\alpha}{2} \Pi^M$$

If these two firms settle out-of-court, each firm has a duopoly profit of Π^D for sure, assuming no further entry:

$$(12) \quad V_A^{NL} = V_B^{NL} = \Pi^D$$

Therefore, they settle if and only if $\alpha \leq \frac{2\Pi^D}{\Pi^M}$.

Now let us analyze the incentive to settle 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:

$$(13) \quad SW^L = \alpha W^M + (1-\alpha) W^C$$

The social welfare with a settlement is given by:

$$(14) \quad SW^{NL} = W^D$$

Therefore, a settlement is preferred from the social planner's viewpoint if and only if $\alpha \geq \frac{W^C - W^D}{W^C - W^M}$.

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

IV. 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 effects of patent pools on a third party's incentives to challenge the validity of patents and on development incentives were also investigated.

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.²² 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. 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.

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

²² 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.

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.

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