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Public Policy toward Patent Pools

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Executive Summary

The past two decades have seen an explosion of patent awards and litigation across a wide variety of technologies, which numerous commentators have suggested has socially detrimental consequences. Patent pools, in which owners of intellectual property share patent rights with each other and third parties, have been proposed as a way in which firms can address this *patent-thicket problem*. The paper discusses the current regulatory treatment of patent pools and highlights why a more nuanced view than focusing on the extreme cases of perfect complements and perfect substitutes is needed. It also highlights the importance of regulators' stance toward independent licensing, grantback policies, and royalty control. We also present case-study and large-sample empirical evidence.

I. Introduction

The past two decades have seen an explosion of patent awards across a wide variety of technologies and a dramatic increase in the volume of patent litigation between rivals. Numerous commentators have suggested that the proliferation of these awards has socially detrimental consequences: overlapping intellectual property rights make it expensive for final good producers to commercialize innovative products and difficult for inventors to move the technological frontier.¹

Patent pools, which can be defined as formal or informal organizations where owners of intellectual property share patent rights with each other and third parties, have been proposed as a way in which firms can address this *patent-thicket problem*.² Indeed, patent pools are already an economically significant institution: a recent estimate suggests that sales in 2001 of devices based in whole or in part on pooled patents were at least \$100 billion.³ Were these suggestions to be adopted, their role might approach that seen in the early days of the twentieth century, when many

(if not most) important manufacturing industries had a patent pooling arrangement.

While the patent pools have been well established in basic manufacturing and electronic industries for decades, they have been increasingly seen as a potential solution for prevalent patent licensing issues in biotechnology-related fields.⁴ Indeed, in the past few years, the biomedical research community has expressed a keen interest in the development of patent pools for biomarkers for cancer, patents relative to HIV / AIDS and SARS, as well as for biotechnologies applied to agriculture and animal cloning. Similarly, the Organization for Economic Cooperation and Development (2002) highlighted the development of biomedical patent pools as an area for future research.

Public policy toward patent pools gradually shifted from an extreme *laissez-faire* approach in the early twentieth century to an outright hostility in the middle of the century.⁵ Only in the late 1990s have pools been examined in a more favorable light by regulators. While patent pools are no longer frowned upon by competition authorities and treated as a collusive agreement among potential competitors, they still raise a number of concerns that optimally should be addressed in order to build a stronger support in their favor and to secure their adoption in the future. This paper aims at pointing out what we know and don't know about patent pools, their general desirability, and the types of covenants that should or should not be included into their charters.

The paper is organized as follows. Section II discusses the current regulatory treatment of patent pools. Section III introduces the basic trade-off between royalty stacking and suppression of competition by looking at the extreme cases of perfect complements and perfect substitutes. It also argues that these two polar cases are of limited use to understand the main regulatory challenges raised by the competition authorities' limited information about the extent of substitutability or complementarity of patents included in the pool. The section also highlights the importance of regulators' stance toward independent licensing (the individual patent holders' ability to license their property independently of the pool), grant-back policies (a requirement by the pool that members turn their future intellectual property to the pool if the latter is deemed essential to a proper working of the technology covered by the pool), and royalty control.

Sections IV and V discuss the social desirability of independent licensing and grant-backs, respectively. Section IV shows that independent licensing goes a long way toward addressing the concerns associated

with the lack of information as to whether a pool is about suppressing royalty stacking or competition. It discusses whether pools that allow independent licensing raise social welfare either *ex post* (price reduction) or from an *ex ante*, Schumpeterian perspective in which innovation is endogenous. Section V discusses the pros and cons of grant-back policies.

Section VI presents the empirical evidence on these two dimensions of pool design. It discusses an analysis of sixty-three patent pools. While this work cannot directly test propositions about social welfare, the evidence largely corroborates the key claims about the considerations driving the formation and structuring of patent pools.

Section VII presents theoretical considerations as well as empirical results on when we expect patent holders to be willing to jump on board and form a pool. Some of the open issues are illustrated in section VIII in a mini-case study about the Motion Picture Experts Group (MPEG)-2 pool. Finally, section IX lists and discusses a few open issues regarding pools. The appendix contains the technical analysis.

II. Current Regulatory Treatment

The recent evolution has been shaped by the regulatory turnaround initiated by the U.S. Department of Justice (DOJ) business review letters of the late 1990s and the even more recent guidelines of the European Commission (April 2004) and of the Japanese Fair Trade Commission (2005). In this section, we present a simplified summary of the U.S. and European policies.

Before doing so, it is worth highlighting the fundamental tension in regulators' views of antitrust activities. Many observers have suggested that patent-thicket problems—where key patents are widely held—affect many emerging industries. Patent thickets may lead to three problems. First, royalty stacking may result: each individual patent holder may charge a royalty that seems reasonable when viewed in isolation, but together they represent an unreasonable burden. Second, even if other firms agree to license their patents at a modest rate, a hold-out problem may result if a single firm then sets a high license fee for its technology. Finally, the very process of arranging the needed licenses may prove to be time consuming. Patent pools thus offer a one-stop shop through which these problems can be avoided.

But as alluded to in the preceding section, patent pools can also have a darker side. By the 1890s, pooling agreements had become commonplace in the United States. Interest in patent pools stemmed in large part from the

desire to avoid the restrictions on anticompetitive activities that had been enacted as part of the Sherman Act of 1890. Patent pools were seen as exempt from regulatory scrutiny, a perception that was buttressed in the 1902 *National Harrow* case, when the U.S. Supreme Court refused to invalidate a patent pool despite the apparent use of the pool by its members to fix prices and reduce competition.

U.S. Department of Justice

As a consequence of the vigorous scrutiny of patent pools in the New Deal and ensuing years, the number of new patent pools formed in the United States dwindled away to almost nothing after World War II. In recent years, however, there has been a cautious revival. In 1995, the DOJ and U.S. Federal Trade Commission issued the “Antitrust Guidelines for the Licensing of Intellectual Property,” which explicitly noted, “cross-licensing and pooling arrangements may provide pro-competitive benefits.”⁶ Shortly thereafter, DOJ’s Antitrust Division issued a favorable review letter concerning the MPEG-2 video patent pool. The result has been a modest resurgence of these arrangements. Numerous steps have been taken by the designers of these pools to avoid antitrust scrutiny, including, in many cases, the submission of the pooling agreement to the Antitrust Division for advance approval.

An initial requirement of the DOJ’s recent reviews of patent pools is that the pool’s charter not include any ancillary restraints. This is easily understood. The creation of a pool should not be a front for an organized division of markets or other cartelization strategies.

The DOJ then requires that the pool contain only “essential patents”: that is, those which are necessary to implement the technology. One implication is that patents within the pool should not be substitutes (internal test). A patent in the pool should also have no substitute outside the pool (external test). By contrast, before 1995, there were almost no provisions relative to the inclusion of essential patents in pools.

Pool members should retain the right to license their property separately (independent licensing). Finally, the DOJ monitors royalty rates and grant-back provisions. For instance, while not explicitly prohibited anymore—among the famous “nine no-nos” that presaged antitrust enforcement in the 1970s was a prohibition against “compulsory assignment of grantbacks” (Wilson 1970)—there is at least some degree of skepticism surrounding grant-backs, in light of the possibility that they will be expanded to encompass nonessential patents. When reviewing the Third Generation (3G) patent pool, the DOJ stated:

The grant-back here, as in other arrangements previously reviewed, is limited to essential patents. By precluding licensors from using the evaluation services or obtaining standardized licenses while holding back their own patents, it makes the portfolio of patents available through the PlatformCo's licensing terms more comprehensive and potentially lowers transactions costs to other licensees. In addition, the assurance that the grant-back obligation here will not extend to other PlatformCos with potentially competing technologies provides an important guarantee against overbreadth. We also understand that a holder of 3G patents can avoid participation in any of the Platform arrangements by not accepting any licenses it needs in the form of Standard or Interim licenses, instead negotiating separately on a bilateral basis with licensors that are Platform members.⁷

European Commission

The European Commission shares the DOJ's concerns about situations when patents that are substitutes are included in the pools, as well as the inclusion of nonessential (and particularly invalid) patents in these arrangements.⁸ They also encourage allowing firms to license patents independently of the pool.

The formal European policies are somewhat more explicit than broad U.S. antitrust guidelines on pools in several respects.⁹ In particular, the European policies explicitly address a broader set of points regarding the structure of these pools:

- The use of an independent expert to determine whether patents are essential is strongly encouraged (an approach that has been followed by recent pools everywhere).
- The presence of a formal dispute resolution mechanism is embraced.¹⁰
- The Commission strongly encourages pools to make the technology available in a nondiscriminatory manner and on reasonable terms.
- Grant-back requirements should be limited to truly essential patents.
- Menus are encouraged, so users do not need to purchase licenses to patents that they don't need.¹¹

III. Royalty Stacking or Suppression of Competition?

Cournot and Bertrand

In some respects the analysis of pools follows the standard regulatory treatment of horizontal and vertical mergers.

Suppose, first, that a technology is covered by n patents, which for expositional simplicity only, are owned by n distinct patent holders. The

patents are *perfect complements* when a user who does not have access to one of them is unable to make use of the technology; put differently, a license to even $n - 1$ patents is equivalent to having no license at all.

With perfectly complementary patents, a user of the technology resembles a shipping company trying to move wares on a barge from A to B along a river or a canal controlled in successive locations by n distinct tax collectors. As Cournot (1838) and Shapiro (2001) have pointed out, users are then confronted with multiple taxations (marginalizations) or, in the context of innovation, royalty stacking. The resulting price for the technology then exceeds the total price (the pool price) that patent holders would jointly set if they coordinated their pricing. Intuitively in this chain of monopolies, each patent holder has gatekeeping power over the technology. When he raises his price slightly, he does not internalize the negative impact of this increase on other patent holders, who see marginal users abandon the technology altogether. As a result, cartel pricing increases both profit and user welfare under perfect complements. Put differently, a pool eliminates royalty stacking and benefits both patent holders and technology users.

Contrast this with the case of *perfect substitutes*, that is, of patents that are distinct and noninfringing, but deliver the same functionality to the users. In the absence of pools, cutthroat (Bertrand) competition among intellectual property (IP) owners results in little or no profit. In the absence of licensing costs, licenses are basically free of charge because undercutting would be too tempting if they were not. Here, a pool is but a merger into a monopolistic arrangement and allows patent holders to suppress competition. Thus, pools of perfect substitutes should be banned.

Reality Is in Between

Cournot's royalty-stacking argument, on which the case for pools is built, relies on perfect or close to perfect complementarity. In practice, though, patents are rarely perfect complements. Additional licenses to one's portfolio increase the number of feasible functionalities and thereby the number of applications that build on the technology without being strictly necessary (indeed, this is the idea behind the European Commission's recommendation that pools offer menus, rather than only the entire package). Furthermore, users may often (at a cost) "design around" existing patents to enable similar functionalities.

As a matter of fact, and even though they rely on experts to determine whether patents are essential, competition authorities are often unsure

as to whether patents are substitutes or complements. Patent holders themselves may not perfectly anticipate the dependence relationship. A case in point is that of the MPEG-2 patent pool discussed later on, in which Lucent refused to include two patents deemed essential and later made far less money licensing than initially anticipated.

Furthermore, the distinction between substitutes and complements is a dynamic one. First patents covering a technology to be adopted by users often are complements at low prices and substitutes at higher prices. At low individual-license prices, users who choose to adopt the technology find it advantageous to opt for an all-inclusive license. When an owner raises his price slightly, he reduces the demand for the overall technology and thereby the demand for the other owners' licenses. By contrast, at high prices, an increase in a license price induces technology users to focus on other patents, that is, to evict the patent from their licensing basket.

Second, the extent of substitutability or complementarity may evolve over time. For example, two patents may be jointly needed to produce functionality A, which is demanded today; but both enable on a stand-alone basis functionality B, which will be demanded tomorrow. In such a case, the patents are complements today and substitutes tomorrow.

Another drawback of the two polar cases is that they are of limited use for an analysis of most policy questions. Pools of perfect complements raise welfare, and those with perfect substitutes lower it. To be sure, independent licensing recreates cutthroat competition in the case of perfect substitutes. But one can alternatively ban the pool. Independent licensing is irrelevant in the case of perfect complements; intuitively, independent licensing can be effective only if users buy all individual licenses, instead of buying them as a bundle from the pool. But royalty stacking then leads to a price above the pool's profit maximizing price, and so the pool is unaffected by the members' ability to grant separate licenses. Somehow, for independent licensing to be a relevant question, there must be some imperfect substitutability or complementarity. Similarly, it is difficult to make sense of the DOJ's internal and external tests in a world of perfect complements or perfect substitutes.

IV. Independent Licensing

The licensors' ability to license their intellectual property independently of the pool creates some potential competition for the pool's offering. Independent licensing (IL), however, raises two related questions:

Impact on the incentives to form a pool and on price moderation: One concern is that an IL requirement imposed by competition authorities might discourage IP owners to form a pool that would otherwise have been beneficial. Conversely, it may be the case that the IL requirement not be sufficient to screen out or sufficiently constrain pools that suppress competition.

Impact on the incentives to innovate: Besides the ex post perspective of looking at whether the pool reduces price (a central focus in merger analysis), one may also (more in the tradition of patent law) take an ex ante or Schumpeterian perspective and consider the impact of allowing pools (with or without an IL requirement) on the inventors' incentives to innovate.

To provide an analysis of these two key questions, we developed in an earlier paper (Lerner and Tirole 2004) an analytical framework that is simple enough to be tractable and yet rich enough to allow for the gamut between perfect substitutes and perfect complements. This framework is discussed in appendix A.

A striking result emerges from this framework: independent licensing perfectly screens out good pools in and bad pools:

1. Independent licensing is an irrelevant covenant when the pool aims at lowering the overall price of the technology below the price that prevails in the absence of pooling arrangement (royalty stacking).
2. Independent licensing restores competition and reestablishes the price of the technology at the prepool level when the pool aims at raising the price of the technology (suppression of competition).

The intuition for this result is particularly easy to grasp in the case of two owners/two patents. Let z_i stand for patent i 's marginal contribution to user surplus; for example, z_2 represents the extra surplus that a user derives from acquiring a license to patent 2 when having already secured a license to patent 1.¹²

In the *absence of a pool*, patent holders cannot charge more than their marginal contributions; otherwise, users would do without it. They can, of course, charge less than this marginal contribution if they feel that a price reduction is more than offset by a strong increase in demand for the overall technology. We are thus led to consider two situations. In the first, at least one patent holder, say owner 1, charges strictly less than his marginal contribution (this is in particular the case if one of the patents is blocking because the owner of such a patent is never worried that

users adopt the technology, but do not acquire a license to his patent). In a generalization of the royalty-stacking argument, and using the idea that each owner is a monopolist on his residual demand curve, it is easy to see that the overall price of the technology then exceeds the one that would prevail if the two owners formed a pool and thereby coordinated their pricing: owner 1 is de facto a monopolist choosing a price \hat{P} for the overall technology and facing marginal cost p_2 (the price charged by owner 2 for a license), that is, the compensation that is to be returned to owner 2. That is, one can consider the fictitious, but economically equivalent situation in which owner 1 pays owner 2 p_2 for the license of patent 2 and sells the bundle of the two licenses to the users. By contrast, a pool chooses a price P^* for the overall technology but has marginal cost $0 < p_2$. Because monopoly prices always increase with marginal cost, a pool lowers price relative to separate licensing ($P^* < \hat{P}$).

The interesting case arises when in the absence of a pool, each owner i charges his marginal contribution z_i . Either $z_1 + z_2 \geq P^*$, and again the pool lowers the price of the technology, or $z_1 + z_2 < P^*$, and then the pool suppresses competition in the absence of independent licensing.

Let us now allow *independent licensing* and ask when the price P (which may or may not be equal to the price P^* that emerges in the absence of IL) is chosen by the pool immune to undercutting by an individual licensor. Owner i can offer the same net surplus to users as the pool by offering his license at price $P - z_j$. If the pool royalties p_j going to owner j (who owns share p_j/P in the pool) exceed z_j , then it is indeed in the interest of owner i to undercut the pool.

Sustainable pool royalties under IL must therefore satisfy

$$p_j \leq z_j,$$

which, together with $p_1 + p_2 = P$, implies that

$$P \leq z_1 + z_2.$$

Conversely, for any pool price P exceeding the sum of the contributions, that is, the price of the technology without a pool, and regardless of the division of the pool's royalties between the two IP owners, the pool will be undercut under IL. The undercutting implies that IP owners end up marketing their property as if the pool did not exist. We conclude that the pool cannot charge a price above the competitive level.¹³

As we noted, competition authorities have little information as to whether patents in the pool are complements or substitutes for various

applications or are likely to remain so. Fortunately, the screening property of independent licensing makes it completely unnecessary for authorities to possess such information. This result is reassuring as we have limited trust in interventions whose suitability depends finely on information that competition authorities do not possess.

The Ex Ante View. We saw that pools with IL always (weakly) lower price and increase welfare from an ex post perspective. But the possibility of forming a pool also affects the firms' incentive to innovate. The option to form a pool augments ex post profits.¹⁴

On the other hand, we also know that incentives to innovate, while often too low, may also be too high from a social perspective. Consider "innovation for buyout," in which an inventor deliberately produces a (noninfringing) innovation with the exact same functionalities as an existing patent.¹⁵ Such a me-too innovation is socially wasteful but may nonetheless be pursued if the inventor knows that his innovation will be purchased by its rival; furthermore, a pool may be the vehicle through which this blackmail pays off. On the other hand, such innovations for buyout do not arise if IL is mandated, as the formation of a pool then does not deliver any profit.

A possible conjecture is, therefore, that *pools with IL are always preferable to no pool from an ex ante, and not only from an ex post, perspective*. This conjecture, which was not proved in our 2004 paper, turns out to be correct: see appendix B. Overall, these results build a strong case for pools as long as an IL requirement is appended.

Discussion. In Lerner and Tirole (2008), we study the impact of independent licensing in broader contexts. Independent licensing does not always weed out bad pools. The reason why is as follows. Suppose, first, that users differ not only in their overall valuation for or costs of implementing the technology, but also in which patents they care about (note that this alone implies that patents are not essential). For example, some users want licenses to both patents 1 and 2, while others care only about patent 1 or about patent 2. The formation of a pool then increases the scope for price discrimination. While under separate licensing all users pay the same price for the license of a patent, a pool offers a menu of choices either by itself or by marketing the bundle and letting members issue individual licenses. Put differently, a pool creates scope for (mixed) bundling. It is well known that price discrimination, per se, can

have a favorable or detrimental impact on welfare. It is, therefore, not surprising that one can find instances in which a pool (even with IL) reduces ex post welfare.

Consider, second, the case of two-sided markets. For example, a software compression technology must be licensed to both hardware manufacturers and music publishers in order to find a market. Suppose that the formation of a pool lowers the price on side A. From the “seesaw” or “topsy-turvy” principle for two-sided markets (Rochet and Tirole 2003; Weyl 2006), a decrease in price on side A makes it less attractive for the technological platform to bring on board side B and leads to a price increase on side B. It is then possible (although unlikely) that a pool reduces ex post welfare.

Finally, our analysis so far has presumed that independent licensors of substitutes would engage in cutthroat competition; this obviously need not be the case; on the other hand, they may also tacitly collude under separate licensing (no pool). The paper compares the scope for tacit collusion under no pool and a pool with IL.

Overall, while the conclusion that independent licensing always screens in good pools and screens out bad ones must be qualified, the case in favor of pools with independent licensing remains quite strong, even from an ex post perspective, in our current state of knowledge.

V. Grant-Backs

Pools may or may not require grant-backs. Grant-back provisions force members of the pool to turn to the pool for free or at a low price future patents that will be deemed essential to the working of the pool. Typically, the determination of whether a patent is essential is left to an outside lawyer, who undertakes the painstaking process of reviewing the detailed claims of each patent. Besides the issues raised by the vagueness of the essentiality requirement, the decision of whether to include a grant-back provision is a complex one from both a private and social perspective.

For the members of the pool, grant-backs have costs and benefits:

- On the cost side, the provision obviously discourages future innovation by pool members. Innovations that would improve the pool’s offering and raise the overall demand for the technology may never materialize. Furthermore, nonmembers may substitute for the missing research

and development (R&D) and either license their patents to the pool or the users at a hefty fee or concur to the development of an alternative technology. One would, therefore, expect grant-backs to be more common when there is limited scope for future innovation.

- On the benefit side, grant-backs provide a check on members' opportunism. For example, a member may have a patent or an innovation in the pipeline, which he, but not the other members, knows is indispensable for a proper working of the technology. This member may refrain from disclosing this information and later attempt a holdup on the pool or its customers. To be certain, such a holdup won't arise if it can be proved that the member deliberately concealed this information; it is, however, rather difficult to bring evidence to this respect.

Whether the members of the pool have an incentive to opt for a grant-back requirement depends on several factors. Obviously, higher uncertainty about the patents that are necessary for the implementation of the technology make the holdup concern more acute and grant-backs more likely. Another factor, studied in Lerner, Strojwas, and Tirole (2007), is the extent of complementarity among pool patents. Suppose that patents A and B, owned by two different owners, are substitutes and that IL is not demanded by antitrust authorities (this was indeed the case for most historical pools). Implementation of the technology may or may not require a license to an "unknown" third and blocking patent C. If the owner of A also owns C, and the owner of B is unaware of the existence of C, then the former has no incentive to join a pool. The combination of the competitive patent and the blocking one gives him full monopoly power; by contrast, by joining the pool, he has to share royalties with his rival as he no longer has access to patent A (recall that IL was not allowed so as to suppress competition). Thus, holdup concerns are less important for pools of substitutes, and we would expect grant-backs to be more common in pools of complements.

A social planner faces some of the same trade-offs with regard to grant-backs. The social planner does not want concerns about potential holdups to hamper the formation of a socially beneficial pool and, therefore, cannot enunciate a *per se* rule against grant-backs. For a social planner, though, grant-backs raise an additional concern: a grant-back policy might be a device to restrict competition in the innovation market. This concern seems more potent when the pool includes all or most players in the relevant innovation market and when essentiality is likely to be interpreted in a rather broad sense.

VI. Patent Pools: The Evidence

It is natural to ask whether these claims about patent pools are borne out when we examine the actual pools that have been formed.

Lerner, Strojwas, and Tirole (2007) test these ideas using a sample of sixty-three patent pools established between 1895 and 2001. As discussed in the preceding, we expect that pools with independent licensing are more likely to be formed when patents are complementary. We also examine the utilization of grant-back provisions. We anticipate that pools of complementary patents are more likely to have these provisions.

In order to undertake this analysis, we must first define what constitutes a patent pool. We define these as cases where either (1) two or more firms combine to license patents to third parties, or (2) three or more firms come together to license patents to share the patents among themselves, or both. This definition excludes several other types of arrangements:

- Simple cross-license arrangements between two firms, where there is no clearly stated intention of engaging in future licensing transactions
- New operating companies that are established to manufacture products based on intellectual property of a number of firms
- Firms that acquire large amounts of patents and then license them to other concerns
- Pools that are dominated by nonprofit entities (e.g., universities), where profit-maximizing considerations may not be paramount

We then compiled a list of all identifiable patent pools, using a wide variety of historical sources. In total, we identified approximately 125 patent pools, dating between 1856 and 2001. We succeeded in obtaining the pooling agreements for 63 of these pools, relying on Congressional hearings during the 1930s and 1940s that scrutinized a number of patent pools, the records of private or federal antitrust litigation, the files of the Antitrust Division of U.S. Department of Justice and the U.S. Federal Trade Commission, and (in the case of recent pools) direct contacts with the pools themselves.

In the preceding theoretical discussion, we distinguish between pools consisting of patents that are substitutes or complements, that is, between pools where the motivation is to avoid Bertrand competition between licensees and those where the goal is to avoid the familiar problem of each party demanding too high a licensing rate. Of course, pools do not come clearly labeled in the real world as consisting of comple-

mentary or substitute patents. Thus, we must employ proxies based on any litigation concerning the pool to identify such awards.

Over the entire period under study, pools have been challenged by private parties for being anticompetitive. For almost the entire time span, the federal government has intervened in challenging pools it believes to be anticompetitive. Thus, the extent and outcomes of the litigation involving the pool may be a reasonable indication of the intentions of the pool founders. This is, to be sure, an imperfect proxy. A variety of criteria weighted into the assessment of patent pools in the pre-1995 era, which only imperfectly map into modern economic criteria for assessing patent pools.

We anticipate that pools that were formed with substitute patents and the goal of dampening competition between licensees were more likely to be litigated. We seek to identify any litigation involving the pool and its outcome, relying upon the sources noted in the preceding, and the media and historical accounts of any litigation involving these pools.

Our empirical work corroborates the theory in two important ways:

- We find in each case that pools that were more likely to have complementary patents—that is, pools that were not litigated or fared better in litigation—were more likely to allow members to engage in independent licensing. These differences are often statistically significant. This pattern holds both in cross-tabulations and regression analyses.
- Turning to the use of grant-back provisions, which require firms to license related IP to the pool, we find that pools that were not litigated are much more likely to require grant-backs. This difference is statistically significant at the 5 percent confidence level. When no remedy involving mandatory third-party licensing was imposed, there is a somewhat greater probability that grant-backs were used. Finally, we show that grant-backs are more positively associated with IL when the pool is not litigated or is subject to less strict remedies regarding licensing. These results are consistent with theoretical suggestions.

VII. Who Joins Pools?

Theoretical Considerations

Antitrust hostility has been the dominant force behind the minor role played by pools in the second half of the twentieth century. But it is not the only hindrance to pool formation, and, despite the wide concerns

about the effects of royalty stacking, we should not expect pools to quite regain their earlier prominence, if only because of the new regulatory requirements concerning pool charters. We now offer some tentative conjectures as to why pools may not form and why, if they form, they may not be as inclusive as would be desirable.

Factors Hindering Pool Formation. There are several factors that make the formation of pools challenging:

Negotiation costs. Forming a pool, as part of or separately from the setting of a standard, involves a protracted process, with substantial legal expenditures. The benefits of forming a pool have to be compared with the resulting costs.

Asymmetric information. The theoretically best-developed cause of bargaining breakdown relates to asymmetries in information (AI) between prospective members. The process of negotiating to form a pool is fraught with AI:

- AI about the value of individual patents
- AI about design-around costs
- AI about future upstream research strategies
- AI about downstream ambitions (when patentees are also licensees)

“Self-imposed or fairness constraints.” In situations in which members have patents of different importance and different design-around costs, have different upstream or downstream ambitions, and so forth, efficient bargaining requires that charters have sufficient flexibility to tailor conditions (royalties, grant-back requirement, etc.) to individual needs and bargaining powers. Yet a surprising number of pools go for an equal treatment for all members. In particular, patents are counted, and royalties per patent are equal to $1/n$ of pool revenues. Such a provision makes sense in the Cournot perfect complements case, at least if patents are truly blocking (no redesign-around possibility), but not in general.¹⁶

Fairness constraints, while they reduce the scope of feasible agreements and reduce negotiation costs, obviously discourage owners of important patents from joining the pool.

Another form of member asymmetry, which we will return to in sec-

tion VIII, relates to the different interests that patentees have in the downstream market. Pure inventors (who have no downstream presence) aim at maximizing royalty income. By contrast, patentees with a substantial downstream presence want low royalties, perhaps a royalty-free arrangement; they further have the possibility to engage in cross-licensing if a pool fails to form. To be certain, bargaining over royalties and transfers between the IP owners in principle could overcome this divergence in objectives. But information gaps, constraints that insure that all parties will be treated uniformly, or other reasons may prevent such deals. Breakdowns of negotiation would seem more likely (at least under uniform treatment constraints) for pools with such conflicting interests.

Factors Facilitating the Emergence of a Pool. There are other considerations, though, that facilitate pool formation:

Gains from trade. The members' gains from forming a pool may come from the elimination of royalty stacking (complements) or the suppression of competition (substitutes). With the advent of the IL requirement, one would expect pools of complements to be relatively more likely to form.

One-stop shopping. We so far ignored the fact that pools economize on users' transaction costs by offering them a single license to the technology. A more difficult question is to identify factors that make one-stop shopping especially attractive. The number of licensors is an obvious guess, although an increase in the number of licensors may also make it harder to negotiate a patent pool arrangement.

User investment and standards. Eliminating royalty stacking is particularly important before users choose to invest in the technology because user demand is more elastic *ex ante* than *ex post*. Hence, distortions induced by royalty stacking are more severe from an *ex ante* perspective. The gain from forming a pool is thus higher when combined with a standard that will induce users to sink specific investments in the technology: see appendix C.

Evidence about Who Joins Pools

Much of the economic analysis of patent pools has focused on their role in competition policy. As such, the theoretical literature has typically

assumed or generated models with the result that all eligible firms wish to join the pool (the one exception is Aoki and Nagaoka 2004). The literature has also often assumed that the distribution of pool earnings among members is flexible enough to entice firms with attractive patents to join the pools (Lerner and Tirole [2004] look at the impact of a variety of distributions).

Layne-Farrar and Lerner (2007) extend the empirical branch of the literature by examining the determinants of joining a patent pool, also providing some preliminary thoughts on the rules that patent pools select for dividing royalty earnings among participants. Using the theoretical literature as a starting point, they develop several hypotheses.

First, they hypothesize that while all kinds of firms can have solid reasons to join a patent pool—including concerns over aggregate royalty rates and technology adoption—firms that conduct R&D and participate in the downstream market for the final good or service are relatively more likely to join a patent pool. These vertically integrated firms have more than one point along the production chain at which to earn their profits (from patent royalties to final product sales). More importantly, these firms are both licensors and licensees as they must obtain cross-licenses from other pool members in order to produce their final good. Both of these factors make them more receptive to pool participation. Relatedly, they suggest that firms may choose to participate in patent pools for products related to but not directly involving their core products in order to enhance the sale of their core products. This strategic use of patent pools lends itself to royalty-free licensing. These firms might view participation in a standard's development and subsequent participation in a related pool as a business expense necessary for maintaining profit levels in key products and services. They are willing to exchange licensing revenue on tangential patents for the broader technology dissemination that patent pools can spur.

They also suggest that firms with relatively symmetric offerings to a new technology are more likely to form a patent pool and may be more likely to agree to proportional sharing rules. For instance, if two firms have both made one crucial contribution to an emerging technology, of rough equivalence in importance to that technology, then these two firms should be willing to pool their patents for licensing and accept equal shares of any patent pool earnings.

Finally, if the value of a firm's contributions to a new technology roughly corresponds to the number of patents that the company contributed, that firm is more likely to accept a proportional sharing rule. In

this case, firms joining the patent pool need not forego equity and efficiency in the name of lower transaction costs, so proportionality is more attractive. Of course, determining the value of a patent's contribution can be extremely difficult. But because modern patent pools tend to grow out of standards, and standards can take years of active debate to define and formalize, the potential members of a patent pool are likely to be quite familiar with the technologies involved and the various members' contributions.

The authors then test against a data set of firms that have either joined or are eligible to join a patent pool, focusing on the more recent pools. Looking across the population of firms that have relevant patents and participate in a standardization effort that forms the basis for a patent pool, they find a number of factors that increase the odds of joining a pool. Most prominent among these are vertical integration (whether the firm manufactures a core product dependent on the standard), the number of patents a firm holds within a standard, and the symmetry between the quality of a firm's patent portfolio and the standard's overall patent contributions. Pools with larger founding member groups tend to have fewer joiners.

They also provide some preliminary thoughts on the roles that patent pools select for dividing royalty earnings among participants. While the authors are unable to analyze these questions as fully as they would like, the various patent citation measures all suggest that firms with higher-value patent portfolios are less likely to join a proportional pool. For those pools choosing a proportional rule, patent value measures are higher for nonpool members, while the reverse holds for value-based pools. Finally, in patent pools, oftentimes the size of pool members' portfolios is highly correlated with measures of the portfolios' value.

VIII. A Mini Case Study: MPEG-2

To gain a richer understanding of the forces shaping patent pooling agreements, we undertook a case study of the MPEG-2 patent pool.¹⁷ MPEG-2 is a digital video compression standard used in products including DVDs and high definition television. The standard was developed by the International Organization for Standardisation (ISO) under the leadership of Leonardo Chiariglione, along with scientists and engineers from many universities and corporations. The standard setting effort began in July 1990, and the final MPEG-2 standard was approved in November 1994. During the completion of the standard setting process,

intellectual property issues became a paramount concern. While all participants in the standard setting process signed a letter of assurance of fair, reasonable, and nondiscriminatory (RAND) licensing, concerns lingered due to the large number of patents required to implement the standard. Even if all individual patent holders licensed their patents on reasonable terms, Chiariglione and other participants were concerned that the sum of all such licenses might not be reasonable.¹⁸

The MPEG Intellectual Property Rights Working Group was thus formed in 1993 to develop a unified approach to MPEG-2 licensing. As the standard materialized, this task was led by CableLabs, an R&D consortium for the cable industry formed in the late 1980s when there was little compatibility among cable systems in the United States. CableLabs was an active participant in the MPEG-2 standard setting process, with the goal of making sure that the resulting standard was consistent with their needs. Baryn Futa, executive vice president and chief operating officer (COO) of CableLabs, gained the trust of participants by chairing the MPEG IP working group. Solutions other than a patent pool were considered, such as a trade association that would function as a clearing-house. But patent holders wanted to ensure that their IP would be aggressively marketed and thus rejected such an association. As a result, CableLabs and other licensors injected \$3 million to found a corporation, MPEG LA, which handled licensing MPEG-2 patents.

Forming the MPEG-2 patent pool and convincing companies to join the pool was complicated due to the different incentives among pool members. These heterogeneous incentives, as well as antitrust considerations, shaped the critical features of the pool.

The most debated issue was the licensing rate that MPEG LA would charge licensees. The primary motive for certain companies was not to maximize licensing revenues, but rather to accelerate the adoption of the standard. For instance, while Sony is both a licensor and licensee of MPEG-2 patents, Sony focuses on maximizing sales of its electronics products and pursues patents as a “defensive mechanism” to protect its IP.

By way of contrast, other organizations such as Lucent and Columbia University wanted to maximize the licensing revenues they received from their MPEG-2 patents. Columbia was particularly motivated to see the pool succeed due to its fears that if a pool were not formed, then MPEG-2 patents would largely be shared via royalty-free cross-licensing agreements. Because the university did not stand to gain by being offered a license to another firm’s technology, in the absence of a

pool, Columbia would be put in the unenviable position of demanding license payments in an environment where no other cash payments were being made for MPEG-2 licenses. While it might be thought that such a condition would allow them to charge higher, rather than lower, royalties, they feared that in actuality, their flexibility in licensing would be sharply reduced. Thus, Columbia's ability to demand a relatively high royalty rate was balanced by its need to ensure that a patent pool emerged.

On the other hand, Lucent took a different approach to the MPEG-2 pool. Lucent had a large internal licensing department with sufficient resources to conduct its own MPEG-2 licensing activities. Moreover, Lucent believed that two of its patents were most critical to the MPEG standard. Lucent felt that the licensing rate established by MPEG LA was lower than it could have been and decided not to join the pool.¹⁹ Lucent estimated that the higher royalty rates it would be able to charge by not joining the pool would more than offset the decreased fraction of the MPEG-2 market that would license its technology if it pursued its own licensing activities.²⁰

The final licensing rate set by the pool was four dollars per decoder for each MPEG-2 system. This one-size-fits-all strategy led to problems in some markets. In some cases, licensees already had licenses to some of the MPEG-2 patents based on broad licensing agreements they had with MPEG LA member firms. In such cases, the licensees have demanded that the rates they are charged be reduced. MPEG LA has handled such situations by telling these firms to negotiate concessions with the individual firms involved in the previous licensing agreements rather than altering the standard MPEG LA licensing terms. A bigger problem occurred in using the same terms for firms in different industries. Computer companies have been reluctant to pay these rates, due to the perceived computer industry norm of not paying royalties and due to the number of features embodied in computers that do not relate to MPEG-2. This led seven MPEG LA pool members to initiate infringement litigation against Compaq and Dell.

Additional clauses in the MPEG LA license agreement were designed to make MPEG-2 licensees comfortable in adopting the technology. The MPEG LA license grants licenses under the future MPEG-2 essential patents of pool members at no additional charge. This provision was viewed as a way to allay the fears of potential licensees that they would be subject to a holdup problem if and when new MPEG-2 patents sur-

faced. The MPEG LA license also commits to not raising the royalty rate unless extreme conditions arise. This clause is also intended to make potential licensees comfortable with committing to use MPEG-2 in their products without the worry of being charged excessively high licensing rates in the future.²¹

The commitment not to raise royalty rates, however, also impacts the ability of the pool to attract new licensors. When a new licensor enters the pool, as any essential MPEG-2 patent holder may do, each existing licensor is diluted: the formula used by the pool for royalty distribution calls for each licensor to receive a pro rata share of the licensing revenues (based on the number of essential patents it owns), while the rate charged to licensees remains constant. This formula was seen as the only feasible formula to avoid controversies regarding assigning value to each individual patent.

The pool was shaped by antitrust concerns as well. Conversations with the DOJ made clear that several features were necessary. These included provisions that (1) licensors would not be precluded from offering licenses under their individual patents, (2) pool membership would be open to any firm with essential MPEG-2 patents, and (3) only essential patents (as determined by outside counsel) would be included.

IX. Final Thoughts

As this essay shows, there are still a number of open questions about the workings and the desirable features of patent pools. Nonetheless, our understanding of pools has improved, and we can draw a few policy conclusions corresponding to our current knowledge. A key insight of this essay relates to the role that an independent licensing provision plays in the formation and performance of the pool.

In a lawyer's language, one might consider offering a safe harbor from antitrust scrutiny, which would allow pools quite generally as long as they (1) serve no ancillary purpose (i.e., traditional collusion or market division) and (2) allow for independent licensing of the individual patents by their respective owners. This essay's analysis suggests that such a policy would simultaneously encourage the development of socially efficient pools (and discourage inefficient ones), while reducing the regulatory uncertainty surrounding the subjective antitrust treatment of pools (who gets to decide whether patents are substitutes or complements, etc.). To the extent that the antitrust enforcement agencies

are interested in designing a policy aimed at enhancing traditional assessments of consumer welfare while maintaining the incentives to innovate, patent pools with an independent licensing allowance are likely to enhance social welfare, from a theoretical as well as empirical or historical perspective. Consequently, whereas pools with these provisions are likely to receive light scrutiny and pools that restrict independent licensing are more likely to receive a higher level of scrutiny, we would not expect such a simple rule to perfectly capture social concerns about patent pools, and so pools would still be subjected to an antitrust scrutiny on a rule-of-reason basis.

Appendix A

An Analytic Framework

Consider a set $I = \{1 \dots, n\}$ of n patents. Let J denote an arbitrary subset and $P(J)$ the total price to be paid for acquiring licenses to the patents included in J . For example, if the licenses are marketed separately at individual prices $\{p_j\}$, then

$$P(J) = \sum_{j \in J} p_j.$$

Alternatively, the licenses can be sold as bundles.

Assume that users differ in some parameter θ and that their net surplus is

$$(1) \quad \theta + V(J) - P(J),$$

where $V(J) \leq V(J')$ when $J \supseteq J'$.²² The $V(\cdot)$ function accommodates a large range of situations, including patents of unequal importance and varying degrees of complementarity or substitutability from perfect substitutes to perfect complements.

User heterogeneity (captured by θ , distributed according to some cumulative distribution function $F(\theta)$) can, for example, stem from differences in the technological or opportunity cost of adopting and adapting to the technology class defined by the set of patents.

The key assumption in equation (1) is that of separability between user type and incremental gains of extra patents.

- *Assuming separability is simple:* Separability implies that (1) in the absence of pool, all adopting users buy the same bundle (the one that max-

imizes $V(J) - P(J)$); (2) it is optimal for the pool to offer the full set of patents and not to license subsets. Put differently, menus are suboptimal for the pool as they cannot be used to capture user surplus.

- *Assuming separability is illuminating:* It allows a clean separation between the “demand margin,” which generalizes the royalty-stacking argument for perfect complements (the demand margin is binding if an individual price increase reduces the demand for the overall basket but does not lead to the exclusion of the corresponding license from the basket selected by users), and the “competitive margin,” which generalizes the notion of competition under perfect substitutes: The competitive margin is binding if an individual price increase implies the eviction of the corresponding license from the basket selected by users.
- *Assuming separability is familiar from the literature:* It is inspired by the nested-decisions approach in the discrete-choice literature. Here, users first select the best basket for the technology and then choose whether to adopt the technology at all. The heterogeneity in θ yields the elasticity of the overall demand for the technology.

Example 1: Design-Arounds

Suppose that all pieces are needed to implement the technology, but individual patents can be designed around. Let $C(K)$ denote the cost of re-designing around the subset of patents K . This function can be separable, $C(K) = \sum_{j \in K} c_j$, where c_j is the cost of designing around patent j ; subadditive, $C(K) + C(L) \geq C(K \cup L)$, that is, there are economies of scope; or superadditive, as when the company has scarce engineering resources. Then

$$V(J) = C(I) - C(I - J).$$

Example 2: Diagnostic Testing

Doctors can use sets of mutations in order to diagnose an illness and decide whether to undertake a treatment. More mutations allow for a better diagnostic, but the function $V(J)$ can have various properties depending on the cross-correlations of errors between the different tests. The net benefit of treating a sick patient is B ; the net damage of treating a healthy one is D .

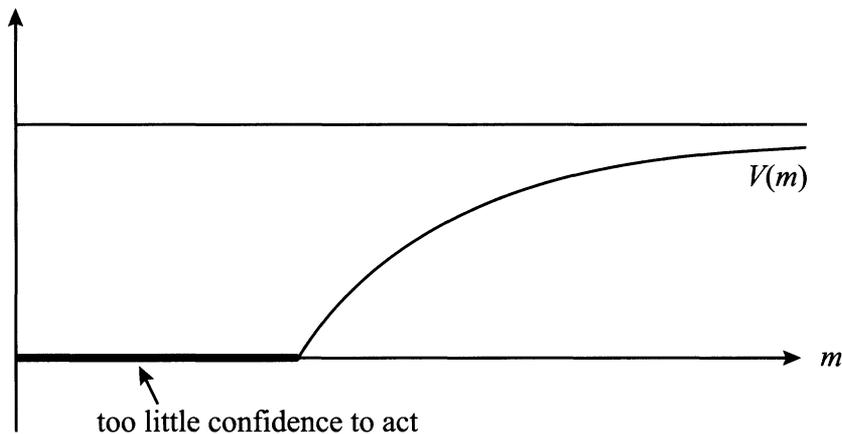


Figure 5A.1
Value function for symmetric, independent patents

For the sake of illustration, suppose that a patient is ill with prior probability x and that a treatment is optimal only if the probability of illness exceeds $p \equiv D/(B + D) > x$. Tests issue false positives, but no false negatives. Let $Y(J)$ denote the probability that tests in J all yield a false positive. Then the posterior probability of illness after only positives is $\hat{x}(J) = x/[x + (1 - x)Y(J)]$. The value function is then

$$V(J) \equiv \max\{0, xB - (1 - x)Y(J)D\}.$$

Figure 5A.1 illustrates the value function for symmetric, independent patents (in which case it depends only on the number of licenses held by the health care facility). The parameter θ can be thought of as being (minus) the opportunity cost of the equipment or of training the doctors to this technology, or as (minus) the value under alternative forms of testing.

For expositional simplicity, let us focus on the symmetric patents case; by abuse of notation, we then write the value function as a function $V(m)$ of the number $m \leq n$ of licenses that are acquired by the user.

- A pool of n patents unconstrained by independent licensing sells at price P^* that maximizes patent holders' profit:

$$PD[P - V(n)],$$

where the demand corresponds to the fraction of users who adopt the technology: $D[P - V(n)] \equiv 1 - F[P - V(n)]$.

- In the *absence of a pool*, individual licensors may be constrained by the following:

- *demand margin*: They then charge individual license price \hat{p} such that \hat{p} maximizes $pD[p + (n - 1)\hat{p} - V(n)]$,

resulting in total price $\hat{P} > P^*$ for the overall technologies (royalty stacking);

- *competitive margin*: Let $z(n)$ denote the (unique) solution to

$$(2) \quad V(n) = np = \max_{m < n} \{V(m) - mp\}$$

and

$$Z(n) = np.$$

$z(n)$ is the maximum price that a patent holder can charge without being evicted from the licensing basket. (Note that if one license is evicted, another may then be evicted as well, so m may be smaller than $n - 1$ in the maximand in equation [2]. For example, in the redesign-around illustration, the eviction of license 1 may trigger the eviction of license 2 if there are returns to scope in redesigning around patents 1 and 2 together.) The magnitude $z(n)$ (or $Z(n)$) is the measure of the complementarity between patents: Figure 5A.2 summarizes the analysis.

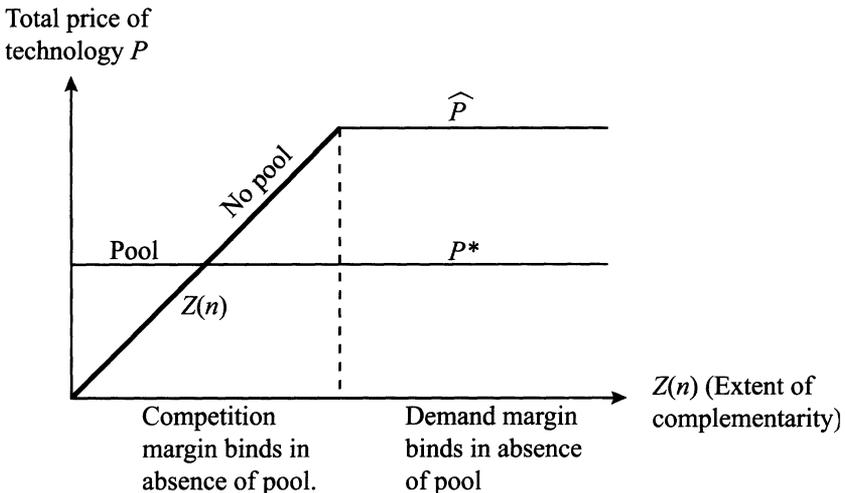


Figure 5A.2
Summary of analysis

Appendix B

Proof That Pools with IL Are, from a Schumpeterian Perspective, Preferable to No Pools

To avoid discussing bargaining powers, let us consider the symmetric case and assume that, if a pool forms, each patent receives $1/n$ of the pool royalties. Let $\Pi_1(n)$ and $P_1(n)$ denote the inventors' total profit and the technology's total price when there are n patents/firms and a patent pool (with IL) is allowed; let $\Pi_0(n)$ and $P_0(n)$ denote the corresponding levels when no pool is allowed. Clearly

$$\Pi_1(n) \geq \Pi_0(n) \text{ and } P_1(n) \leq P_0(n) \text{ for all } n$$

(the pool ex post always weakly increases profit and weakly reduces the technology's price).

At the ex ante stage, (a large number of) firms choose whether to innovate. Without loss of generality, let K_i denote the corresponding investment cost, where K_i is (weakly) increasing in i . We will also assume that if there are several free-entry equilibria, then the one with the largest number of firms prevails. That is, for $k \in \{0,1\}$, n_k is the highest number such that $[\Pi_k(n_k)]/n_k \geq K_{n_k}$ and $[\Pi_k(n_k + 1)]/(n_k + 1) < K_{n_k+1}$.

This implies that

$$n_1 \geq n_0$$

(intuitively, higher ex post profits trigger more innovation ex ante).

Revealed preference then implies that

$$V(n_1) - P_1(n_1) \geq V(n_0) - P_1(n_0)$$

(since the pool, for any n , maximizes $PD[P - V(n)] \equiv [\tilde{P} + V(n)]D(\tilde{P})$, where $\tilde{P} \equiv P - V(n)$ is the net price. Revealed preference implies that \tilde{P} is decreasing in n). And so, because a pool with IL always lowers the price [$P_1(n_0) \leq P_0(n_0)$],

$$V(n_1) - P_1(n_1) \geq V(n_0) - P_0(n_0).$$

Thus, users are always made better off than in the absence of pool.

Appendix C

User Investment and Benefits from Forming a Pool

In the framework defined in appendix 1, suppose that there are two stages—ex ante and ex post.

The optimal pool price is

$$P^*_{\text{ex ante}} = \arg \max\{PD_{\text{ex ante}}[P - V(n)]\} \text{ ex ante}$$

and

$$P^*_{\text{ex post}} = \arg \max\{PD_{\text{ex post}}[P - V(n)]\} \text{ ex post.}$$

Assuming that ex post demand function is less elastic than the ex ante one,

$$P^*_{\text{ex ante}} < P^*_{\text{ex post}}$$

By contrast, the competitive margin, and therefore $Z(n)$, are the same ex ante and ex post.

Suppose that pools must allow for independent licensing. Then only pools that reduce the technology's price form. And, if

$$P^*_{\text{ex ante}} < Z(n) < P^*_{\text{ex post}}$$

there is a benefit for the patentees to forming a pool ex ante, but no such benefit ex post.

Endnotes

Draft prepared for the 2007 National Bureau of Economic Research (NBER) Innovation Policy and the Economy Conference, Washington, DC, April 12. We are grateful to Scott Stern for helpful comments on an earlier draft.

1. Gallini (2002) and Jaffe and Lerner (2004) review this literature.
2. For example, these have been proposed by Merges (1999), Priest (1977), Shapiro (2001), and the U.S. Patent and Trademark Office (Clark et al. 2001).
3. See Clarkson (2003).
4. See, for instance, Delmer et al. (2003); Ebersole, Guthrie, and Goldstein (2005); Van Overwalle et al. (2006); and Verbeure et al. (2006).
5. In *Bement v. National Harrow Co.* (186 U.S. 70 [1902]), the U.S. Supreme Court, ruling on a patent pool, stated that "the general rule is absolute freedom in the use or sale of rights under the patent laws." In *Hartford Empire v. U.S.* (323 U.S. 386 [1945]), U.S. Supreme Court Justice Black, also referring to a patent pool, stated that "the history of this country has perhaps never witnessed a more completely successful economic tyranny."

6. See <http://www.usdoj.gov/atr/public/guidelines/ipguide.htm>.

7. See <http://www.usdoj.gov/atr/public/busreview/200455.htm>.

8. See the Commission's guidelines on the application of Article 81 of the European Commission Treaty to technology transfer agreements (2004/C 101/02), April 27, 2004. Similarly, in ¶216 of its guidelines on the application of Article 81 of the European Commission Treaty to technology transfer agreements (2004/C 101/02), April 27, 2004, the European Commission states that "A technology is essential as opposed to non-essential if there are no substitutes for that technology inside or outside the pool and the technology in question constitutes a necessary part of the package of technologies for the purposes of producing the product(s) or carrying out the process(es) to which the pool relates."

9. The U.S. policies are codified at <http://www.usdoj.gov/atr/public/guidelines/0558.htm> (see especially section 5.5).

10. ¶235:

"Finally, it is relevant to take account of the dispute resolution mechanism foreseen in the instruments setting up the pool. The more dispute resolution is entrusted to bodies or persons that are independent of the pool and the member's thereof, the more likely it is that the dispute resolution will operate in a neutral way."

11. ¶222:

"The Commission will in its overall assessment, *inter alia*, take account of the following factors: (c) whether, in cases where the pooled technologies have different applications some of which do not require use of all of the pooled technologies, the pool offers the technologies only as a single package or whether it offers separate packages for distinct applications. In the latter case it is avoided that technologies which are not essential to a particular product or process are tied to essential technologies; (d) whether the pooled technologies are available only as a single package or whether licensees have the possibility of obtaining a license for only part of the package with a corresponding reduction of royalties. The possibility to obtain a license for only part of the package may reduce the risk of foreclosure of third party technologies outside the pool, in particular where the licensee obtains a corresponding reduction in royalties. This requires that a share of the overall royalty has been assigned to each technology in the pool. . . ."

12. Implicitly, we assume that this contribution is independent of the user's demand for the technology; that is, we make a separability assumption: see appendix A for a description of the framework.

13. With more than two patent owners, any price that exceeds the price that would prevail in the absence of a pool is weakly unstable, in that if the pool attempted to charge such a price for the technology, there would exist an equilibrium in which independent licenses are sold at the no-pool prices, and the pool does not sell.

14. In our discussion of dynamic incentives, we abstract from the strategic aspects of patent races under the prospect of pool formation. How these prospects affect the intensity of competition in the R&D market is analyzed in Dequiedt and Versaveal (2006).

15. This terminology is inspired by Rasmussen's (1988) "entry for buyout."

16. This holds when each member contributes one patent to the pool. More generally, with m members, the Cournot model and, say, the Nash bargaining solution predict that each member gets $1/m$ of the royalties (having one or more blocking patents makes no difference if they are truly blocking).

17. This section is based on interviews with current and former employees from five different organizations that participated in or negotiated with the pool. In addition, we spoke with Leonardo Chiariglione, the vice president of Multimedia at Telecom Italia Lab, the research center of Telecom Italia. Finally, we spoke with a representative from MPEG LA, the corporate entity formed to administrate the pool.

18. It should be noted that considerable ambiguity surrounds the definition of what constitutes RAND licensing. A number of standard-setting bodies we talked to were unable to provide a precise definition of what constituted a reasonable royalty. For instance, one group indicated that they used 5 percent as an upper bound, but did not distinguish between cases where the rate applied to the individual component and the entire system.

19. Lucent was also constrained by licensing policies that were established as part of a 1956 consent decree settling federal antitrust litigation against Western Electric.

20. So far, this has not been the case, as MPEG-2 licensees generally have been willing to pay Lucent no more than the per-patent rate charged by MPEG LA for licenses under Lucent's MPEG-2 patents. The failure of Lucent to reap attractive returns from its holdout strategy may appear initially puzzling. The seller of a complementary good should be able to charge more when other firms cut their prices. Industry observers, however, argued that substantial uncertainty surrounded the determination of the proper royalty rate for patents. MPEG LA's decision to set a low rate may have been seen as a signal of the patents' value, leading to a reduced willingness to license Lucent's complementary patents at a high rate.

21. In point of fact, the royalty rate has subsequently been lowered to \$2.50, even as the number of patent families covered by the pool has expanded from 25 to 118.

22. This formulation allows for the possibility of user downstream competition: see Lerner and Tirole (2004) paper for more details.

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