Title
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1. Introduction

Intellectual property rights are widely recognized as critical assets in many industries, especially "high-tech" industries. Companies like IBM, Intel, and Hewlett-Packard regard their patents and copyrights, along with their other intangible assets such as know-how, as central elements giving them competitive advantage. Likewise, many software companies, from Microsoft to software startups seeking funding from venture capitalists, recognize that copyright protection is essential if they are to recoup their expenditures developing new software. Put simply, patents and copyrights are often the crown jewels in a high-tech company's collection of assets.[1]

Intellectual property rights, while by no means the only way for firms to recoup their investments in research and development, are of increasing strategic importance in a range of industries, including semiconductors, networking equipment, and biotechnology as well as software.[2] And now, with patents being issued for "business methods" like Amazon's one-click shopping, software patents are poised to have a major impact on the commercialization of the Internet.[3] To cite one very recent example, InterTrust Technologies recently sued Microsoft for patent

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[1] For simplicity, in this paper I shall typically refer to "patents" rather than "intellectual property" more generally. Apart from differences in the legal treatment of different forms of intellectual property, virtually everything in this paper could be applied equally to copyrights, or even trade secrets, as well as patents.

[2] The increased propensity of companies to file for patents and the use of defensive patenting has been well documented. See, for example, Kortum and Lerner (1998), Grindley and Teece (1997), Cohen et. al. (2000), and Hall and Ziedonis (2001).

[3] Patent applications for computer-related business methods jumped from about 1000 in 1997 to over 2500 in 1999.

infringement associated with Windows Media, software that Microsoft plans to include in the new version of Windows, Windows XP, set to come out in August 2001. With InterTrust requesting an injunction to prevent Microsoft from violating the InterTrust patent, this suit, like many others, could potentially have a dramatic impact on competition, in this case for software that handles digital-rights management. As is common in these disputes, the lawsuit followed failed attempts to negotiate a license, and multiple patents are involved; InterTrust asserts that it holds 18 U.S. patents and has filed applications for 47 others.[4]

The increasing importance and number of patents and copyrights inevitably is leading to more and more intellectual property *disputes* between rights holders and alleged infringers. In fact, since many products can potentially infringe *multiple* patents, the number of disputes, or the number of licenses needed to resolve those disputes, can easily grow more than proportionately with the number of patents. As I have described elsewhere, more and more companies are facing a *patent thicket* requiring them to obtain multiple licenses to bring their products to market.[5] No doubt the majority of intellectual property disputes are settled rather than litigated to a final resolution.

The need to negotiate licenses or other settlements of intellectual property disputes is made even greater because of the danger of hidden or submarine patents, which make it all too easy for a company unintentionally to infringe on a patent that was not yet issued when the company's product was designed.[6] Likewise, the need to resolve intellectual property disputes is arguably made yet greater to the extent that the U.S. Patent and Trademark Office has issued "bad" patents, i.e., patents on technology that does not in fact meet the novelty requirement. Many critics have charged that the PTO has had a poor understanding of prior art, especially in the software area, and improperly issued a number of patents.[7] Bad or not, there is no dispute that

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[4] Don Clark, "Microsoft is Sued by Tiny InterTrust in Patent Dispute," *Wall Street Journal*, April 27, 2001.

[5] See Shapiro (2001). For some thoughtful proposals to reform the patent system, see Merges (1999).

[6] Recent reforms to disclose some patent applications prior to the issuance of the patent should alleviate, but not eliminate, this problem. The ability of those applying for patents to revise their patent applications over time tends to exacerbate this problem.

[7] There are many striking examples of such "bad" patents. For a few entertaining accounts of the problem, see Simon Garfinkel, "Patently Absurd," *Wired*, July 1994, Evan Ratliff, "Patent Upending," *Wired* , June 2000, and

the number of patents being issued is growing dramatically. In short, a compelling case can be made that intellectual property disputes are of increasing importance in determining just which firms can compete in which markets, and on what terms.

A wide range of commercial arrangements involving intellectual property can be regarded as settlements of intellectual property disputes, either literally (in the sense that litigation has been initiated and is dropped once an agreement is reached) or effectively (because negotiation takes place in the shadow of possible litigation). Virtually 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. Mergers and joint ventures are yet more ways to settle patent disputes.

Given the importance of patents and their licensing to innovation, and given the many commercial arrangements that are effectively settlements of intellectual property disputes, the legal rules governing the resolution of such disputes are of first-order importance. This importance is not confined to high-tech industries, much less to the software and Internet sectors, but extends to all industries where intellectual property rights are significant. In a very real sense, the rules governing settlements affect what is truly meant by the patent grant itself. In fact, in many fast-moving industries, the rules governing patent litigation and settlements are arguably far more important to patentees than the single variable on which economists have traditionally focused, namely patent length.[8]

James Gleick, "Patently Absurd," *New York Times Magazine*, March 12, 2000. See also Lerner (2000) for an in-depth look at financial patents, including the (in)famous patent in the *State Street* case, a key court ruling supporting the notion of patents on business methods. But do not despair: there is now a web site that will help those accused of infringing find prior art and thus invalidate the patent asserted against them. See www.bountyquest.com.

[8] The importance of patent litigation, and thus rules governing settlements, varies across industries and by type of patent. For a study of how the frequency of court cases varies with characteristics of patents and their owners, see Lanjouw and Schankerman (2001).

A number of different rules can materially affect the value of the patent grant.[9] Under what conditions can a patent holder obtain a preliminary injunction blocking another firm from producing products that allegedly infringe the patent? How long does patent litigation take, and what is the state of competition during the *interim* period while patent validity and infringement are being resolved in court? How are patent damages calculated: lost profits, reasonable royalties, or unjust enrichment/disgorgement?[10] When do treble damages apply for "willful" infringement? What protection does the patent holder have from an infringer who is judgment-proof, i.e., simply lacks the assets to satisfy a damages award?

My focus in this paper is on one particular class of legal rules that govern intellectual property rights: the *antitrust limits* imposed on patent settlements. The need for some basic antitrust limits should be obvious. Suppose that Firm A has a fairly weak and fairly narrow patent that it is asserting against its sole rival, Firm B. The two firms are competing vigorously, with Firm B evidently not deterred from competing just because Firm A has sued it for infringement. Suppose that Firm B believes that the patent likely to be invalid, but even if valid that Firm B is not infringing, or as a final option that Firm B could easily design around the patent. Now imagine that Firms A and B agree to merge to resolve their patent dispute. If the merger would judged anti-competitive in the absence of the patent, there is no reason to believe that this one weak patent would reverse that conclusion. Or imagine that Firms A and B agree to a settlement under which Firm B pays significant per-unit royalties to Firm A and Firm A makes a fixed payment to Firm B. Such settlements can replicate the cartel or monopoly outcome.[11]

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[9] I am not even including here the whole range of rules that determine patent validity and patent breadth, such as the standard for novelty, the procedures by which the PTO looks for prior art, the ability of the applicant to modify its patent application, the rules for disclosure of patent applications prior to issuance, the ability of third parties to challenge the patent either prior to its issue or immediately upon issuance, the burden of proof in infringement validity and infringement cases, the rules governing interferences (when multiple contemporaneous patent applications conflict with each other), and the implementation of the doctrine of equivalents. Patent rules in the context of sequential innovation have been studied by Chang (1995), Scotchmer (1996) and O'Donoghue (1998) among others.

[10] See Schankerman and Scotchmer (2001) for a comparison of two liability rules, lost profits/reasonable royalties and unjust enrichment, and a property rule, injunctions, in terms of protecting intellectual property, focusing on research tools.

[11] See, for example Michael L. Katz and Carl Shapiro, "On the Licensing of Innovations," *Rand Journal of Economics*, Winter 1985.

Precisely because patent settlements can be anti-competitive, and because settling parties may have an incentive to insert anti-competitive provisions into their agreements, antitrust interest in the settlements of intellectual property disputes is very high. The 1995 DOJ /FTC *Antitrust Guidelines for the Licensing of Intellectual Property* describe generally how the agencies will analyze various commercial agreements involving intellectual property.[12] In 1997, a clear statement of concern about settlements was voiced by then Assistant Attorney General Joel Klein, who even floated the idea of having companies notify antitrust officials of their settlements of patent disputes.[13] More recently, senior antitrust enforcement officials have spoken repeatedly about intellectual property rights and their role in the new economy.[14]

Beyond these general statements, however, we can observe a number of cases in which the Justice Department and the Federal Trade Commission have investigated and/or challenged settlements that they regarded as anticompetitive, or expressed views regarding the antitrust limits on patent settlements. I shall refer to several such cases below, but pause here to note two examples. After Digital Equipment Corporation sued Intel for patent infringement, Intel settled with Digital by purchasing certain assets from Digital and entering into a supply agreement with Digital. The FTC issued a complaint and required modifications of the settlement agreement.[15] When six companies (Toshiba, Hitachi, Matsushita, Mitsubishi, Time Warner, and JVC) sought

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[12] "Antitrust Guidelines for the Licensing of Intellectual Property," Department of Justice and Federal Trade Commission, April 6, 1995, available at http://www.usdoj.gov/atr/public/guidelines/ipguide.htm.

[13] See Joel I. Klein, "Cross-Licensing and Antitrust Law," May 2, 1997, available at http://www.usdoj.gov/atr/public/speeches/1123.htm. Currently, companies entering into certain exclusive licensing arrangements must notify the government under the Hart-Scott-Rodino Act, as some exclusive licensing arrangements have been interpreted as involving the acquisition of assets.

[14] See, most recently, FTC Chairman Pitofsky's speech, "Antitrust and Intellectual Property: Unresolved Issues at the Heart of the New Economy," March 2, 2001, available at http://www.ftc.gov/speeches/pitofsky/ipf301.htm and Deputy Assistant Attorney General Joseph Farrell's speech, "Thoughts on Antitrust and Innovation," January 25, 2001, available at http://www.usdoj.gov/atr/public/speeches/7402.htm. For broader discussions of antitrust and intellectual property, see Gilbert and Shapiro (1997) and Gilbert and Tom (2001).

[15] See the FTC's Complaint In the Matter of Digital Equipment Corporation, available at http://www.ftc.gov/os/1998/9807/9810040cmp.htm, and the Agreement Containing Consent Order, available at http://www.ftc.gov/os/1998/9804/9810040.agr.htm.

to jointly license their patents necessary to the production of DVD discs and players, the DOJ issued a business review letter approving their plan subject to certain conditions.[16]

Within the area of antitrust limits on settlements, the current paper is fairly ambitious. In the next section, I discuss generally the benefits and costs of settlements and explain more fully why antitrust limits on settlements are unquestionably needed to prevent abuse of the settlement process. Then, in Section 3, I propose and develop a general rule for evaluating proposed settlements, namely a requirement 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. My proposed rule is designed to fully respect intellectual property rights, while emphasizing that such rights are inherently uncertain or imperfect, at least until they have successfully survived a challenge in court. My proposed rule is also intended to enable a wide range of settlements that can enhance efficiency and promote competition without depriving rights holders of their legitimate returns to invention. I prove a very general result showing that in virtually all cases settlements exist that are better for consumers as well as the settling parties in comparison with ongoing litigation.

The balance of the paper then applies the general rule to three different types of settlements. For each type of settlement, I develop some basic theory and describe some actual settlements in this category where antitrust issues have arisen. Section 4 handles mergers. Section 5 covers negotiated entry dates. Section 6 covers patent pools. Section 7 summarizes my conclusions and outlines some ways in which my analysis can be extended.

Two interesting by-products of this analysis are worth noting. First, I develop a "Patent Competition Index" which measures of extent of competition between two parties who are engaged in a patent dispute. This intuitive measure tells us how large must be the efficiencies associated with a merger (i.e., the complete elimination of competition) between the two parties in order for such a merger to be better for consumers than ongoing litigation and competition. Second, in various settings I am able to derive the relationship between the profits earned by the

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[16] See Justice Department Business Review Letter of June 10, 1999, available at http://www.usdoj.gov:80/atr/public/busreview/2485.htm.

patent holder and the *strength* of its patent, as defined by the probability that the patent will be held valid and infringed if patent infringement is litigated to a resolution.[17] As I show below, in a number of settings the patent holder's expected profits are *not* linear in patent strength, so a patent with a 50% chance of being upheld is not necessarily worth half as much as an ironclad patent covering the same patent claims.

2. Benefits, Costs, and Dangers of Patent Settlements

A. Benefits and Costs of Settlements

Settlements of litigation generally are recognized to provide a number of private and social benefits. Private benefits include the avoidance of litigation costs and the resolution of uncertainty. Social benefits include savings on court costs and/or reduction of congestion in the court system. Social costs can include the lack of resolution of a legal issue with applicability beyond the individual case at hand. Generally speaking, the courts have strongly favored settlements, if nothing else just to reduce their case load and speed up the resolution of remaining matters.

Unlike many other settlements of litigation, settlements of patent litigation between rivals by their very nature implicate competition, and thus tend to have effects on third parties, most notably (but not only) customers of the litigating parties. Patent settlements certainly can enable the settling parties to compete more effectively with others, as when two firms with complementary patents agree to a cross-license enabling each of them to make higher-quality products or achieve lower production costs. But patent settlements can also enable the settling parties to restrict competition between themselves, to the detriment of consumers. Consumers may suffer from lost rivalry, both during the interim period while patent litigation would have continued, and perhaps in the longer term as well, at least until the patent expires. Settlements can deprive consumers not only of competition between the settling parties, but from other firms as well if an invalid patent is never actually challenged.

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[17] Various empirical papers have attempted to measure the value of real-world patents. See, for example, Lanjouw (1998) and Schankerman (1998).

B. Unconstrained Settlements and Their Dangers

Patent settlements present as especially tricky area for antitrust because of the undisputed pro-competitive benefits that can result from a wide range of settlements, including the vast majority of patent licenses. Such pro-competitive settlements are by no means confined to settlements between rivals, but certainly can include such cases. Drawing the line between "price fixing agreements" and "pro-competitive licensing arrangements" is not a simple matter. But the need to draw some line should not be in dispute.

Suppose that two rivals can settle their patent dispute with no antitrust limits. Of course, they still must successfully reach an agreement to settle their dispute, and this may be difficult for the usual reasons that negotiations break down, including potentially asymmetric information (more specifically, optimism on both sides about their prospects in litigation). But for now let us assume that the two firms bargain efficiently and thus reach a settlement that maximizes joint profits. What do such settlements look like?

It is immediately evident that such settlements could be used to eliminate competition that would have arisen had the patent holder lost. By eliminating such competition, monopoly profits can be enjoyed, even if the patent was very weak, or even worthless. There are many ways that such settlements could be structured: (1) the patent holder could acquire the challenger, with the purchase price set in some mutually agreeable fashion to split the gains from trade, including the gains from eliminating competition; (2) the patent holder could make a fixed payment to the challenger in exchange for the challenger's agreement not to compete, either at all or in certain product areas, geographic areas, or during some specified time period; (3) the two companies could enter into a joint venture or other cooperative arrangement (such as a supply agreement or co-marketing setup) whereby they both participate in the market without directly competing against each other; or (4) the challenger could agree to pay certain per-unit royalties to the patent holder in conjunction with a fixed payment running from the patent holder to the challenger. The only requirements for such profit-maximizing settlements are (a) that they preserve the monopoly power that the patentee would have had in the absence of the challenger, and (b) that each party find it individually rational to accept the settlement rather than continue to litigate.

A hallmark of these anti-competitive agreements is that the patent holder agrees to share its monopoly profits with the challenger in order to induce the challenger to give up its fight. In the merger context this is clear: the challenger is paid the acquisition price. A bald payment not to compete is even more explicit (and difficult to justify). A joint marketing program could also explicitly share the monopoly profits with the challenger. But note that the use of running royalties to monopolize typically will not be acceptable to the challenger unless the challenger also receives a fixed-fee payment (see below for the analysis of such two-part tariff schemes).

Clearly such agreements will tend to be contrary to the interests of consumers: with limits on patent settlements, consumers will receive only the surplus available facing a monopolist. Such settlements can deprive consumers of the advantages that competition, or at least its prospect, would have offered to them, during the interim period prior to the resolution of the patent dispute and subsequently, if the patent would have been declared invalid or not infringed, or had the challenger found a practical way to invent around the patent.

C. Patents as Partial Property Rights

It is important to bear in mind that the monopoly profits that can be (jointly) achieved through unconstrained settlement do *not* merely represent the rights granted to the patentee by virtue of having obtained the patent in the first place. A patent is best viewed as a *partial* or *probabilistic* property right. What the patent grant actually gives the patent holder is the right to sue to prevent others from infringing the patent. Nothing in the patent grant guarantees that the patent will be declared valid, or that the defendant in the patent suit will be found to have infringed. In other words, all real patents are *less strong* than the idealized patent grant usually imagined in economic theory.

A real patent may prove to be less valuable than the idealized patent in several distinct ways. (1) The real patent may be found invalid, either in whole or in part (if certain broader claims are declared invalid, perhaps based on prior art, but some narrower claims are upheld). (2) The real patent may be found not to be infringed by a given product sold or process employed by another firm. (3) The real patent may be relatively easy for others to invent around rather than pay royalties or be forced to cease production. (4) The real patentee may be unable to obtain a preliminary injunction to prevent alleged infringement. (5) The real patentee may not be able to

receive as a judgment all of its lost profits that result from infringement, e.g., if the infringer's assets are insufficient to satisfy the award.

In this paper, I shall take as given the bundle of uncertain and imperfect rights that we call a "patent." These rights are typically far less valuable than would be idealized "ironclad" patent rights. In my view, the patent holder is not "entitled" to obtain the same level of profits, or the same rights to exclude rivals, as would the owner of the fictionalized ironclad patent. Therefore, the patent holder is not "entitled" to negotiate a monopoly outcome, just because the patent holder *asserts* that its patent is valid and infringed by a particular rival. Rather, the patent holder's rights are calibrated according to the likelihood that the patent holder would win the patent litigation, and the extent of exclusion that such a victory would permit. Generally, these rights are not as strong or as valuable as the rights of a full-fledged monopolist owning an ironclad, blocking patent.

3. Proposed Principle: Settlement Cannot Harm Consumers

Given the obvious incentive to use settlements to replicate the monopoly outcome, and given that the patent grant is not the same as an ironclad right to monopoly profits, antitrust limits on settlements are clearly needed. At the same time, a prohibition on settling patent disputes cannot make sense: as noted earlier, virtually every patent license can be viewed as the settlement of a patent dispute, and more generally settlements can provide many benefits not only to the settling parties but to consumers as well. Since many settlements are pro-competitive, in the sense that consumers are better off under the settlement than they would be from ongoing litigation, overly strict antitrust limits, not to mention a ban on settlements, would clearly be counterproductive.

So, we must face the complex question of how to draw the line between acceptable and unacceptable patent settlements from an antitrust perspective. In this paper, I propose and explore in some depth the following simple antitrust rule: a patent settlement cannot lead to lower expected consumer surplus than would have arisen from ongoing litigation.

I believe that this standard has much to commend itself. In particular, I argue that this standard balances the rights of patentees with consumer interests. Effectively, consumers have a "property right" to the level of competition that would have prevailed, on average, had the two

parties litigated the patent dispute to a resolution in the courts. So long as consumers rights to this level of competition/benefits are respected, the two parties are permitted to negotiate more profitable arrangements that are better than litigation for each of them as well as consumers.

My proposed standard balances the rights of patent holders with those of consumers.[18] Since patents involve "partial" or "probabilistic" property rights, as discussed above, patent holders are *not* entitled to the same level of profits that would be result from an ironclad patent covering the same patent claims. Put differently, competition that would take place under the shadow of patent litigation is considered entirely legitimate, even though it may wind up constituting infringement. Lurking behind this view are two broad assumptions worth making explicit: (1) I take as given the intellectual property rights regime, with its necessary imperfections, such as the granting of patents that will later be found invalid and the chance that the holder of a valid patent may not be able to obtain an injunction to stop what turns out to be actual infringement; (2) I take as given the damages regime associated with patent infringement, including both the rules for calculating damages and the fact that patentees may not be able to fully collect on damage awards in some cases, e.g., if the infringer declares bankruptcy or is beyond the Court's reach.

My proposed standard for patent settlements also is consistent with how antitrust policy and law treat other forms of collaboration among competitors. A proposed merger, for example, is usually judged to be pro-competitive if consumers are better off under the proposed merger than they would be in the absence of the merger. The same standard is used for joint ventures and co-marketing arrangements between direct rivals.[19] Likewise, under the FTC/DOJ *Guidelines for the Licensing of Intellectual Property* (cited above), licenses are generally regarded as pro-competitive if they do not restrict competition that would have taken place in the absence of the license. Of course, in practice it may be difficult to compare consumer surplus under two

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[18] Antitrust enforcement (such as merger review) often uses a consumer-welfare standard rather than a total-surplus standard. Clearly, a short-run consumer-surplus standard is not sensible when intellectual property rights are involved: declaring all extant intellectual property rights invalid could well maximize short-run consumer surplus, but at the obvious expense of longer-term innovation and consumer interests. Indeed, it is hard to articulate an alternative standard that encourages innovation in the long-run, efficient commercial arrangements in the short-run, and still protects consumers from cartel-like settlements.

[19] For a more general discussion of the limits on collaboration, see the DOJ/FTC "Antitrust Guidelines for Collaboration Among Competitors," available at http://www.ftc.gov/os/2000/04/ftcdojguidelines.pdf.

different arrangements due to imperfect information about industry conditions.[20] And antitrust enforcement of patent settlements may well require an informed judgment as to the strength of various patents that are at issue.

An alternative antitrust rule, less favorable to settling parties, would look not only at the effects on consumers of their overall agreement, as I am proposing here, but also at the effects of specific *provisions* in the agreement. Under a full-blown "less restrictive alternative" approach, an agreement would be declared anti-competitive if an *alternative* agreement could have been fashioned, perhaps by removing or modifying certain provisions in the original agreement, that would be even better for consumers than the proposed agreement.[21]

Clearly, taken to an extreme such an approach would *not* in fact respect intellectual property rights. Consider, for example, the case of two holders of complementary, blocking patents who agree to place their patents into a pool and license them jointly at an agreed-upon royalty rate. As shown in Section 6 below, such a pool can easily be in consumers' interests, in comparison, say, with independent licensing programs by the two firms, since independent licensing runs into

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[20] Some of the practical issues regarding available information can be seen in the antitrust treatment of price and output agreements between competitors. Consider an agreement between two rivals, one much more efficient than the other, according to which the inefficient firm will cease production and purchase its output from the efficient firm at a pre-specified transfer price. If the two firms have a large share of the market, this type of "tolling agreement" or "contract manufacturing" scheme will likely be viewed with skepticism by the antitrust authorities. This skepticism is not easily overcome, despite the obvious possibility of achieving lower production costs, even if the two parties assert that the transfer price will be low enough so that total output will be higher than would arise in the non-cooperative duopoly equilibrium involving these two firms. But this skepticism derives from a lack of confidence that consumers will in fact be better off under the proposed joint venture/tolling agreement, given its susceptibility to abuse, not from an unwillingness to accept such agreements in principle if they indeed leave consumers better off. These same concerns arise with several forms of patent settlement, as I discuss below. All of this suggests to me that, as a practical matter, the actual degree of competition between the two parties prior to the settlement is of paramount importance, inasmuch as it indicates the likely level of competition that would prevail (in the near future at least, unless market conditions are known to be changing in a significant way) in the absence of the settlement.

[21] Some support for this approach might be found in §4.2 of the DOJ/FTC Intellectual Property Guidelines (1995), which state that "If the Agencies conclude that the restraint has, or is likely to have, an anticompetitive effect, they will consider whether the restraint is reasonably necessary to achieve procompetitive efficiencies." They go on to state "If it is clear that the parties could have achieved similar efficiencies by means that are significantly less restrictive, then the Agencies will not give weight to the parties' efficiency claim. In making this assessment, however, the Agencies will not engage in a search for a theoretically least restrictive alternative that is not realistic in the practical prospective business situation faced by the parties." So long as the initial determination that the agreement has anti-competitive effects is made in comparison with ongoing litigation, this approach is identical to the one explored here.

the problem of Cournot complements. Just as clearly, however, consumers would be better off (in the short run) if the two firms agreed to a royalty-free cross license, as each could then compete independently with no licensing cost burden. But compelling such a cross-license in favor over the patent pool could well deprive both firms of a return on their R&D that led to their patent. I do not expect to resolve this debate here, which arises in other areas of antitrust; I merely note that the standard I explore here may not be universally accepted.

A. Pareto Optimality and Gains from Settlement

I now prove a general result showing that there are invariably gains from settling a patent dispute, even ignoring the savings associated with reduced litigation costs and uncertainty.

Consider two firms that are actual or potential competitors who are engaged in a patent dispute. Firm #1 we will call the *patent holder* or the *incumbent*. Firm #2 we will call the *alleged infringer*, the *challenger*, or the *entrant*. There are a number of possible outcomes of their patent dispute, if it is litigated to completion; we index these states of the world by $w = 1,...N$. For example, one state might be that the patent is declared invalid. A number of other states might correspond to various levels of cost required for the challenger to invent around the patent. This framework is quite general: a finding of non-infringement would correspond to a zero cost of inventing around the patent; a finding that some of the broader claims in the patent are invalid while narrower claims are valid would correspond to lower, but still positive, costs of inventing around the patent. Suppose that both sides agree that the probability of state w is q_w.[22]

The general antitrust rule explored in this paper is that a settlement should be permitted if it leaves consumers at least as well off as they would be, in expected value, from ongoing litigation and resolution of the patent dispute in court. Denote consumer surplus in state w by S_w. This is a reduced-form that incorporates whatever duopoly (or oligopoly) solution concept applies in the

[22] Obviously, the two firms may well have asymmetric beliefs about the likelihoods of the various states of the world. Indeed, it is mutual optimism that tends to lead to litigation rather than settlement. The proper treatment of asymmetric information, including possible updating of beliefs based on settlement offers, is beyond the scope of this paper. Unless otherwise indicated, I shall generally assume the two firms share common beliefs about the probabilities of various outcomes in their patent dispute. Relaxing this assumption leads to a rich area for further research.

various states of the world. If resolution of the patent dispute takes time, then S_w includes consumer surplus during the interim period while the dispute is litigated. To the extent that information is revealed gradually, and the firms' behavior can adjust (e.g., to preliminary court rulings), consumer surplus will vary somewhat with the state of the world even before that state is fully revealed.

With these definitions, the expected consumer surplus from ongoing litigation is

$$\bar{S} = \sum_{w=1}^{N} q_w S_W \qquad (1)$$

The profits earned by firm i in state of the world w (in the absence of any agreement between them) are denoted by p_{wi} with joint profits in state w given by $p_w = p_{w1} + p_{w2}$. The expected joint profits from ongoing litigation are

$$\bar{p} = \sum_{w=1}^{N} q_w p_W \qquad (2)$$

Now suppose that the two parties can write detailed contacts that specify their actions in each state of nature. Denote their specified actions by $x_w = (x_{1w}, x_{2w})$ in state w. Denote by $p(x_w)$ the joint profits corresponding to action x_w.[23] Denote by $S(x_w)$ the consumer surplus associated with action x_w.[24] If we require that any negotiated settlement satisfy the surplus constraint (1), the two parties will solve

$$\max_{x_w} \sum_{w=1}^{N} q_w p(x_w) \quad \text{s.t.} \quad \sum_{w=1}^{N} q_w S(x_w) \geq \bar{S} \,. \qquad (3)$$

Since the weights on the profit and surplus functions across the states of nature are identical, the solution to this maximization necessarily involves solving the sub-problem of

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[23] Note that the profit *function* itself is not indexed by the states of nature. Recall that the states of nature correspond to the outcome of the patent litigation and thus the resolution of property rights; they do not reflect the resolution of any fundamental uncertainty about underlying cost or demand conditions.

[24] Again, since the states of nature correspond to resolution of uncertainty about property rights, not demand, the surplus function itself is not indexed by the state of the world.

$$\max_x p(x) \quad \text{s.t.} \quad S(x) \geq \bar{S} \qquad (4)$$

and then replicating this solution across all states of nature. In other words, the firms should negotiate a set of actions that maximizes their joint profits subject to the surplus constraint and then follow this same set of actions regardless of how the patent litigation would have been resolved. Call this (constrained) optimal set of actions x^*. If the firms acted differently from x^* in any state of nature, they could do better by taking action x^* instead in that state of nature and leaving their actions in all other states of nature unchanged.

The underlying idea here is that the two parties should efficiently product consumer surplus. There is no reason for the two parties to introduce randomness into their actions, just because they face initial uncertainty about the strength of the patent holder's property rights. The implication is that there are *always* Pareto Optimal settlements available, so long as different outcomes would have prevailed in different states of nature under litigation.[25] This is a very strong and very general "gains from settlement" theorem.

***Proposition #1, Gains From Settlement*: If the actions of two rival firms engaged in a patent dispute would vary depending upon the outcome of their patent dispute, there is always a Pareto-Improving settlement available. Under the profit-maximizing *ex ante* settlement that leaves consumers whole, the firms' *ex post* actions do not vary with the *ex post* property rights of the patentee.**

In fact, the more variation there would be in the outcomes under the various states of nature, the greater are the available gains from settling the dispute.

By showing that there are always gains from settlement I do not mean to minimize various practical considerations that come into play when antitrust authorities attempt to evaluate the impact on consumers of patent settlements that are actually proposed. Most notably, antitrust authorities may have difficult determining the probabilities of the various states of the world,

[25] I shall use the term "Pareto Optimal" to refer to agreements that benefit both parties to the dispute as well as consumers as a group. This includes agreements that benefit some consumers and harm others, so long as consumers, taken as a group, are better off.

particularly inasmuch as this requires a technical assessment of one or more patents and their various claims.[26]

Proposition #1 has an immediate implication regarding the value of uncertain patent rights when settlement is possible. To illustrate what is a more general point, suppose that there are only two outcomes of litigation: the patent holder "wins" or "loses," with the former state yielding higher profits for the patent holder and lower profits for the challenger. The probability that the patent holder "wins" will be called "patent strength." Now, we know (by definition) that the patent holder's payoff from litigation is linear in patent strength. We also know that the gains from the optimal permissible settlement are zero if the patent strength is either zero or unity, but positive for intermediate values of patent strength. Assuming that the patent holder receives some positive fraction of the gains from the optimal settlement, the patent holder's payoff from settling cannot be linear in patent strength, and exceeds the linear interpolation of value in between a worthless patent and an ironclad patent.

***Proposition #2, Value of Patent is Not Linear in Patent Strength*: Suppose that there are only two outcomes of the patent litigation. Call the probability of the outcome more favorable to the patent holder the "patent strength," q. The patent holder's payoff under the optimal settlement is not linear in patent strength. A patent with strength q is worth more than q times a patent that will receive the more favorable outcome with certainty.**

B. Benefits of Optimal Settlement: Price/Quantity Examples

We can illustrate these gains from settlement more concretely when the firms are picking prices and quantities. In fact, for a given set of products, we know a great deal about the solution to equation (4), since it is the dual to the standard Ramsey pricing problem.

Suppose the incumbent firm produces a single product, the demand for which is denoted by $x = D(p)$ where p is price and x is output. Call the monopoly price p_M with corresponding

[26] This raises an interesting legal question: settling parties often have their own assessments of patent strength that are subject to attorney-client privilege and thus are not revealed to either the antitrust enforcement agencies or the courts. One possible approach is for the challenger, asserting for antitrust purposes that the patent was strong (and

consumer surplus S_M. To keep things simple, suppose that there are only two states of the world: either the incumbent wins the patent case and has a monopoly, or the challenger wins the patent case and a duopoly results. Let us suppose that the incumbent will win the patent case with probability q, which we call *patent strength.* If the entrant wins the patent litigation, the duopoly price will be p_D with corresponding consumer surplus S_D and joint profits p_D.

The expected consumer surplus if the parties do not settle is given by

$$\bar{S} = qS_M + (1-q)S_D .$$

Call $\bar{p}$ the price that generates surplus level $\bar{S}$. The optimal settlement subject to the consumer surplus constraint involves a price of $\bar{p}$ in all states of the world. In other words, we must have

$$S(\bar{p}) = qS(p_M) + (1-q)S(p_D) . \qquad (5)$$

Since $S'(p) = -D(p)$, we know that $S''(p) = -D'(p) > 0$, so the surplus function is convex in price. Therefore, equation (5) implies that $\bar{p} < q\,p_M + (1-q)\,p_D$. In other words, consumers must receive a lower price on average from settlement than they would get from litigation. This result follows from the fact that consumer benefits grow disproportionately as price falls.

***Proposition #3, Settlement Must Lower Average Price*: If the two parties to a patent dispute sell a single homogeneous product, the price that prevails under their settlement must be *less* than the average price that would result from litigation, if the settlement is to be in consumers' interests.**

We can measure the gains from settlement if we are prepared to make some stronger assumptions about costs, demand, and duopoly behavior. Suppose that demand is linear, $D(p) = A - p$ and marginal costs are a constant, c. The monopoly price is $p_M = (A+c)/2$.

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thus competition limited without a settlement), to waive its privilege and share its internal assessment with antitrust enforcers.

1. Bertrand Competition

If the firms are Bertrand competitors, then $p_D = c$. The consumer surplus function is $S(p) = (A-p)^2/2$. Consumer surplus under Bertrand pricing is $S_D = (A-c)^2/2$. Calculating consumer surplus under monopoly and under duopoly, the price $\bar{p}$ must satisfy

$$\bar{p} = A - \frac{A-c}{2}\sqrt{4-3q}\,.$$

By construction, consumers are just as well off under the settlement as from litigation. By how much do profits, and thus total welfare, rise under settlement? With litigation, total expected profits are $qp_M = q\frac{(A-c)^2}{4}$, since there are no profits under duopoly. With settlement, profits are $p_S = (\bar{p}-c)D(\bar{p}) = \frac{(A-c)^2}{4}(2\sqrt{4-3q}+3q-4)$. The extra profits (welfare) made possible by settlement as a fraction of the monopoly profits are given by

$$G \equiv \frac{p_S - qp_M}{p_M} = 2\sqrt{4-3q} + (2q-4).$$

Naturally, these gains from settlement are zero if there is no uncertainty, i.e., if q is zero or one. But for intermediate levels of q, this measure of the gains from trade is non-trivial. For example, if $q = 1/2$, G equals 0.16. In other words, one-sixth of monopoly profits can be captured as extra profits from settlement without harming consumers.

If we assume that the patent holder and the challenger split the gains from trade associated with the settlement, the overall payoff to the patent holder is given by $qp_M + Gp_M/2$ which equals $p_M(2q-2+\sqrt{4-3q})$. Note that this expression is concave in the strength of the patent, so the patent holder's payoff is concave in patent strength. A patent with strength one-half is worth *more* than half as much as an ironclad patent, as we know more generally from Proposition #2.

How would the optimal agreement be implemented? Since we are assuming Bertrand pricing competition with homogeneous products, the desired price $\bar{p}$ can be achieved if the challenger pays a royalty equal to $\bar{r} = \bar{p} - c = \frac{A-c}{2}(2-\sqrt{4-3q})$. Compare this with the royalty that

would support the monopoly outcome, $r_M = p_M - c = \frac{A-c}{2}$. The "allowed" royalty as a fraction of the monopoly royalty is given by $\bar{r} / r_M = 2 - \sqrt{4-3q}$, which is increasing and but not linear in the strength of the patent, q.

Given this royalty, we can ask next whether both firms would find the settlement individually rational; put differently, is a fixed payment required to facilitate the optimal agreement, and if so in which direction does the payment run? This question is easy to answer given the rather stark nature of Bertrand competition. Without a settlement, the entrant would earn no money, even if it wins the patent suit; for the same reason, the entrant earns no money under the license, either, since the resulting price just equals the entrant's costs: $\bar{p} = c + \bar{r}$. So the entrant is indifferent to the agreement in the absence of any fixed fees. We know that joint profits are higher under the agreement than under litigation, by construction, so in the absence of any fixed fees the incumbent captures all of the gains from trade. If we think in terms of Nash Bargaining, for example, we would expect the incumbent and entrant to split these gains from trade, which would imply a fixed payment running from the incumbent to the entrant. For the reasons discussed above, such fixed payments can be abused if antitrust enforcement agencies lack sufficient information to directly check that consumers are not harmed by the settlement in comparison with ongoing litigation, which may difficult if antitrust enforcers are unable to assess patent strength.

2. Cournot Competition

Turn now to the companion case in which the firms are Cournot competitors. This case differs from the Bertrand case in that consumers benefit less from the possibility of successful entry, and the entrant makes positive profits if it wins the patent suit. I continue to assume that the entrant is equally efficient to the incumbent (and marginal costs are constant), thus abstracting away from issues of how to achieve production efficiency in the context of a settlement.

The Cournot Duopoly price is given by $p_C = \frac{A+2c}{3}$. Performing the same type of calculation as was done above in the Bertrand case, the settlement price under Cournot competition is

$$\bar{p}_C = A - \frac{(A-c)}{6}\sqrt{16-7q}\ .$$

This outcome could be supported through a settlement in which the entrant pays per-unit royalties sufficient that the resulting Cournot equilibrium gives this price. If the royalty rate is r, the resulting Cournot equilibrium price is $\frac{A+2c+r}{3}$. The corresponding royalty rate is $\bar{r} = \frac{(A-c)}{2}(4-\sqrt{16-7q})$.

We can again ask whether the two firms would find this royalty individually rational, or more generally what range of fixed fees would be required to make this agreement mutually acceptable. I focus on the challenger's profits, to see whether a payment from the patent holder to the challenger is needed to make settlement at the optimal royalty rate acceptable to the challenger. With no settlement, the challenger earns the Cournot duopoly profits if it wins the patent suit. Since the profits of each Cournot duopolist are given by $p_{1C} = p_{2C} = (A-c)^2/9$, the challenger's expected profits from litigating are given by $(1-q)(A-c)^2/9$. Modest calculations show that the challenger's profits from settling at the royalty rate $\bar{r}$ are

$$p_{2S} = \frac{(A-c)^2}{9}(\sqrt{16-7q}-3).$$

The challenger's gains from settlement are given by $p_{2S} - (1-q)p_{2C}$. Substituting and simplifying, we get the gains from settlement to the challenger as

$$G_2 = 2(A-c)^2(4-q-\sqrt{16-7q}).$$

Of course, there are no gains to the challenger if there is no uncertainty, i.e. if $q=0$ or $q=1$, because the settlement just replicates the certain outcome in these polar cases. For all intermediate values of q, the challenger is strictly better off under the settlement in the absence of a fixed payment running in either direction. This is important, because it implies that no fixed payment from the patentee to the challenger is required to implement the optimal settlement. Since it is exactly such payments that raise antitrust concerns, this is an encouraging result: the optimal royalty should be acceptable to the challenger without the use of a fixed payment, which

could be abused by the settling parties if antitrust enforcers lack the information (such as patent strength) needed to check that the consumer surplus constraint is satisfied.[27]

3. Rationalization of Production

In both of these cases I assumed that the two firms had constant and equal marginal costs of production, so the mix of production between the two firms was irrelevant from the perspective of production efficiency. What about the case in which the two firms have, in general, different costs as a function of output, and in which marginal costs are not constant?

If there are economies of scale in production, the optimal settlement involves one firm shutting down. But for this settlement to meet the consumer-surplus constraint, the other firm will typically have to produce more than the monopoly output. Assuming that the antitrust authorities do not want to engage in direct regulation of the remaining firm, some type of supply agreement is needed to insure that output is sufficiently large that consumers are not disadvantaged.[28] Such supply agreements can work well in theory, enabling competition while taking advantage of economies of scale, but present a range of problems in practice, especially if costs are uncertain and likely to change over time.

Even in the absence of strong scale economies, efficiency can still be promoted by rationalizing output across the two firms, especially if one firm is considerably more efficient that the other. Consider, for example, the case in which the patent holder is primarily a research outfit that can engage in some manufacturing, whereas the challenger has a large, established, manufacturing presence (for related, non-infringing products) and is far more efficient at production. The obvious solution here is for the challenger to obtain a license to the patent. But some degree of "inefficient" production by the patent holder may be needed to protect consumers from paying monopoly prices set by the licensee. Structuring the license with a higher fixed fee and lower running royalties can also help insure that the resulting price is low enough to satisfy the consumer-surplus constraint, but this solution may not be enough.

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[27] If such a check can reasonably be done, then efficient settlements can be further encouraged by giving the parties greater latitude to reach settlement by using cash payments.

4. Differentiated Products

In many cases the challenger offers a product that is distinct from the offerings of the patent holder. Clearly, efficient provision of consumer surplus may well involve preserving both products under the terms of the settlement. In general, if efficiency requires both products to be produced, the two parties can use per-unit royalties and fixed-fee payments to move around their reaction curves and thus induce a Bertrand pricing equilibrium that replicates the optimal settlement. However, the resulting contract may require per-unit royalties running from the patent holder to the challenger, which tends to raise its own antitrust concerns. (In this respect, settling litigation in which each party is asserting patents against the other can provide more flexibility to the settling parties.) If such payments are prohibited, the primary tool remaining to influence the Bertrand equilibrium is the royalty rate pay by the challenger to the patent holder. But the fully optimal settlement may not be obtainable as an induced Bertrand equilibrium. And an outright merger might well not satisfy the consumer-surplus constraint, unless the merger would generate its own efficiencies.

4. Mergers and the Patent Competition Index (PCI)

I turn now from a general discussion of the benefits from settlement to an analysis of specific types of settlements, which occupies the remainder of this paper. I begin in this section with the most inclusive form of settlement, namely an outright merger between the two parties to the patent dispute. Two real-world examples (along with the Digital/Intel example noted earlier) illustrate the types of mergers studied here. The first example is the acquisition by Boston Scientific of Cardiovascular Imaging Systems (CVIS). Boston Scientific, a large company that makes a range of medical equipment, was producing and selling certain imaging catheters that CVIS, a small company, claimed infringed its patents. To settle the dispute, Boston Scientific acquired CVIS. The FTC required that Boston Scientific license the CVIS patents as a condition

[28] These same issues come up when firms seek to merge and offer as an antitrust "fix" a joint venture or supply agreement to preserve competition while taking advantage of economies of scale.

for approving the merger.[29] A second, more recent example is the acquisition by Gemstar of TV Guide. Gemstar asserted that TV Guide's "interactive program guides," basically on-screen interactive information about TV program listings, infringed Gemstar's patents. Gemstar offered its own guides. After years of litigating and competing against Gemstar, TV Guide agreed to be acquired. The DOJ did not challenge this merger.[30]

A. The Patent Competition Index

Suppose that the two firms engaged in the patent dispute agree to merge, completely eliminating competition. Consumer surplus under a merger, assuming no efficiencies, is just the level from monopoly, S_M. Expected consumer surplus from ongoing litigation has already been defined as $\bar{S}$, so the merger will cause a loss of consumer surplus of $\bar{S} - S_M$.

Compare this to the loss of consumer surplus that would result from a merger between these two parties if the challenger were known *not* to be infringing the patent, i.e., if the challenger were not under the cloud of possible infringement. Call consumer surplus in the state of nature in the which the patent is held to be valid but not infringed, S_D, reflecting duopoly competition between the two firms.[31] Under these conditions, the loss of consumer surplus from a merger would be $S_D - S_M$. I call the ratio of these two measures of harm to consumers the "Patent Competition Index," which is meant to calibrate the degree of competition between the two firms in comparison with a conventional merger without the patent component. The Patent Competition Index (PCI) is defined as

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[29] See "Boston Scientific to Help Launch New Maker of Cardiac Catheter to Settle FTC Charges Over CVIS, Scimed Acquisitions," February 24, 1995, available at http://www.ftc.gov/opa/predawn/F95/boston.scient.htm. See also http://www.ftc.gov/opa/1995/9505/boscvis.htm, announcing the license with Hewlett-Packard. But note also that the DOJ later sued Boston Scientific for failing to license all the patents and provide all the interface information to H-P as required under its agreement with the FTC; http://www.ftc.gov/os/2000/10/bsccmp.htm.

[30] For more information about Gemstar and its business plans, see "Henry Yuen Wants to Be Your TV Guide," *Fortune*, August 14, 2000, and "TV Guy: Will Gemstar-TV Guide's Henry Yuen Take Control of Your TV Set?" *Business Week*, March 12, 2001.

[31] Note that this duopoly outcome corresponds to a valid patent for which the challenger has a zero cost of inventing around, which is equivalent to non-infringement. This is not, however, the most favorable possible state of nature for consumers. Consumers may be yet better off if the patent is held invalid, if that would lead to greater actual or potential entry. In fact, for precisely this reason, $\bar{S}$ could actually exceed S_D. This situation would correspond to a Competition Index greater than unity.

$$PCI = \frac{\bar{S} - S_M}{S_D - S_M}. \qquad (6)$$

If the patent is valid but the challenger would surely be found not to have infringed, then $\bar{S} = S_D$ and the Patent Competition Index is one. If the patent is valid and totally blocks the challenger, then $\bar{S} = S_M$ and the PCI is zero. If the patent would certainly be found invalid, enabling more entry, then $\bar{S} > S_D$ and the PCI is *greater* than unity.

Besides giving a sense of how much competition may be lost as a result of a proposed settlement involving a full merger, the PCI also tells us how large the *efficiencies* associated with the merger must be, relative to the efficiencies that would be required to justify a merger *without* the patent overlay. Call the extra consumer benefits flowing from efficiencies associated with the merger *E*. Call the minimum such benefits that would make a conventional merger attractive to consumer E_D: $S_M + E_D = S_D$. Likewise, call minimum such benefits that would make the proposed settlement attractive to consumer $\bar{E}$: $S_M + \bar{E} = \bar{S}$.

Now we can take the ratio of these two efficiency measures, $\bar{E} / E_D$ to compare the efficiency hurdle that the settlement must clear, versus a conventional merger, to be in the interests of consumers. Since $\bar{E} = \bar{S} - S_M$ and $E_D = S_D - S_M$, this ratio is precisely the Patent Competition Index: $PCI =$. In other words, the PCI can also be interpreted as the magnitude of efficiencies required to make the settlement pro-competitive, calibrated to the efficiencies that would be required of a conventional merger in which the challenger does not face a patent "cloud" over its ability to compete. I record this simple arithmetic in the form of a Proposition:

Proposition #4, Efficiencies Necessary for Consumers to Benefit from a Merger Settlement: **Suppose that a conventional merger between two firms would need to generate efficiencies causing extra consumer surplus of *E* to benefit consumers. Then a patent settlement between these two firms must generate efficiencies causing extra consumer surplus of *PCI*E* to benefit consumers, where PCI is the Patent Competition Index, from** (6)**.**

So long as there is some degree of competition between the merging parties, either prior to the settlement or in prospect in the absence of a settlement, a merger cannot benefit consumers

unless it generates at least some efficiencies. In other words, the fact that there is a patent cloud of some type hanging over the challenger reduces, but does not eliminate, the need for merger efficiencies to offset anti-competitive effects.[32]

B. Calculating the Patent Competition Index

I now derive the Patent Competition Index in a several specific cases.

1. Immediate Resolution of Patent Litigation

Suppose that the patent litigation could be resolved instantly and there are only two possible outcomes. With probability q, the patent holder wins, in which case the challenger is totally blocked from the market. With probability $1-q$, the challenger wins, in which case the challenger is found to not infringe the patent (but the patent is still valid). In this simple case, we have $\bar{S} = qS_M + (1-q)S_D$, and direct calculations show that $PCI = 1-q$. In other words, the Patent Competition Index directly tracks the weakness of the patent.

Consider a variation on this example in which the challenger winning means that the patent is held invalid, thus leading to *more* competition than would arise under duopoly (with other potential entrants still deterred to some degree by the patent). Calling consumer surplus with the invalid patent S_I, we have $\bar{S} = qS_M + (1-q)S_I$. Suppose that patent invalidity generates a multiple k incremental surplus to consumers as does duopoly (in comparison with monopoly): $S_I - S_M = k(S_D - S_M)$, where $k > 1$. Then we have $PCI = k(1-q)$. If the patent is not too strong, and if invalidity generates significantly more consumer surplus than mere non-infringement, i.e., if other firms can take advantage of the invalidity ruling, then a merger

[32] An extension to this paper would be to integrate this analysis with traditional structural merger analysis based on measures of market concentration. The safe-harbor provisions in merger enforcement can reasonably be viewed as indicating the magnitude of efficiencies that are credited to merging parties as a matter of course. Presumably, a somewhat greater increase in concentration would be permitted if the acquired firm is operating under a patent cloud. One could, in principle, calculate and apply new safe harbor concentration measures that permit greater increases in concentration when *PCI* is lower.

causing the patent suit to be dropped may face a *higher* hurdle in terms of efficiency than a plain vanilla merger involving the same companies in which the challenger is known not to infringe.[33]

Next, consider the case in which losing the patent litigation does not completely exclude the challenger from the market but simply imposes a cost penalty on the challenger as a result of the need to invent around the patent.[34] We can capture this in reduced form through the consumer surplus function $S(c)$, this being consumer surplus if the challenger's cost of inventing around the patent is c. In terms of our earlier notation, $S(0) = S_D$, and $S(c) = S_M$ for large values of c. Consumer surplus under litigation is thus $\bar{S} = qS(c) + (1-q)S_D$.[35] As above, calibrate $S(c)$ according to $S(c) - S_M = g(S_D - S_M)$, where now $g < 1$. In this case, we get $PCI = qg + (1-q)$. Note that in this case the Patent Competition Index is no less than g, even if the patent is ironclad, and of course equals unity if the patent is very weak $(q \approx 0)$.

We can always convert the Patent Competition Index to specific efficiencies that the merger must enable, given enough structure in terms of cost and demand functions and oligopoly behavior. To illustrate, consider again the case with linear demand, $D(p) = A - p$, constant marginal cost for each firm of c, and Bertrand competition. The duopoly outcome involves price at marginal cost, in comparison with the monopoly price of $(A+c)/2$, so $E_D = S_D - S_M = 3(A-c)^2/8$. Since we have $PCI = (1-q)$, we know that the settlement must generate efficiencies of $\bar{E} = (1-q)E_D = 3(1-q)(A-c)^2/8$. If the settlement permits a reduction of marginal costs of Δ, then the resulting price is $(A+c-\Delta)/2$ and the associated efficiencies are $\bar{E} = \Delta\dfrac{2(A-c)+\Delta}{8}$. To meet the required level of efficiencies, the per-unit cost savings must

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[33] A complete analysis would account for the probability that *another* challenger would continue ahead with litigation and prove the patent invalid. Of course, the holder of a weak patent might settle with a series of challenger to avoid just this outcome.

[34] Inventing around could also take time. See the next subsection for a discussion of cases in which competition varies over time.

[35] I have returned to the assumption that a victory by the challenger means that the challenger is held not to be infringing, but leaves the patent intact. I do not develop here the general case in which there are many possible outcomes of the patent litigation, involving different values of c and perhaps patent invalidity as well.

satisfy $\frac{\Delta}{A-c}(2+\frac{\Delta}{A-c})=3(1-q)$. Since consumer benefits are convex in the cost saving, the per-unit cost saving necessary if $PCI=1/2$ is *more* than half of the cost saving that would be required to justify a conventional merger.

2. Delayed Resolution of Patent Litigation w/ No Interim Competition

What about the realistic case in which the patent litigation takes some time. More precisely, what about the case in which the settlement occurs well before the patent litigation would likely be resolved in the courts?

In this case, we must explicitly keep track of the passage of time and recognize that competitive conditions can change over time. Call the date of the settlement time $t=0$, and the expiration of the patent date $t=1$. Define the *interim* period to be the period, $[0,T]$ until the patent litigation would be resolved in the courts.[36] To keep things simple, I assume that demand conditions, and the presence or absence of other firms, does not vary over the time interval $[0,1]$, and I will assume a zero interest rate. Relaxing these assumption would be straightforward but add considerable complexity of the resulting expressions.

To focus on the timing and the possible differences between the interim period $[0,T]$ and the subsequent time period $[T,1]$, let me return to the case in which a victory by the challenger would lead to a standard duopoly situation (i.e., would mean a finding of patent validity but non-infringement). If the challenger would choose *not* to compete during the interim period,[37] then consumer surplus under litigation would be $\bar{S}=TS_M+(1-T)(qS_M+(1-q)S_D)$. In this case, the Competition Index is $(1-T)(1-q)$.[38] We get the same result if the challenger is not *allowed* to

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[36] In practice, this period can be broken down further. For example, there may be preliminary rulings that cause the parties to update their beliefs about the ultimate outcome of the resolution. There also may be a ruling in the lower court that is subsequently appealed.

[37] For example, makers of generic drugs challenged by patent holders typically do not enter until after receiving a favorable ruling on infringement, because their damage exposure – based on the profits lost by the maker of the branded drug – tend to be far higher than the profits that the generic maker can earn through entry.

[38] If we allowed for a positive interest rate, then the Competition Index would be somewhat lower, reflecting the fact that the period of competition only comes after the period of monopoly.

compete because the Court has issued a preliminary injunction ordering the challenger to cease its possible infringement.

3. Delayed Resolution of Patent Litigation with Interim Competition

A more interesting situation arises if the challenger *would* choose to compete during the pendency of the patent litigation. For example, in the Gemstar/TV Guide merger, TV Guide continued to offer its interactive program guides to cable companies, along with patent indemnification, while under the threat of Gemstar's patent suit. If the actual level of competition and consumer surplus during the pendency of the patent suit can be observed, the PCI is relatively easy to calculate directly.

To study how competition is likely to play out under the shadow of patent liability, we must specify the liability to which the challenger is potentially exposed by infringing the patent. Clearly, such liability will tend to impede the challenger's ability to compete effectively. Call the consumer surplus resulting from competition between the incumbent and the challenger facing potential liability for infringing S_L. Then we have $\bar{S} = TS_L + (1-T)(qS_M + (1-q)S_D)$. As above, calibrate the consumer benefits associated with the "impeded" duopoly, S_L, according to $S_L - S_M = PCI_L(S_D - S_M)$ where $PCI_L < 1$ and where PCI_L is smaller, the stronger is the patent and the more favorable to patent holder are the damages rules in patent infringement cases. With these definitions, the Competition Index turns out to be $T * PCI_L + (1-T)(1-q)$. Now consumers get some benefits even during the interim period, depending upon how strongly the challenger will compete under the shadow of possible liability for infringement.

I now explore just how vigorously the challenger would compete if it decides not to withdraw and wait, i.e., what determines the value of PCI_L. In one central case, I establish that $PCI_L > 1-q$, so consumer benefits during the interim period are even larger than they will be (on average) after the patent dispute is resolved.

Of course, to analyze the challenger's behavior, we need to specify the legal rules governing the calculation of damages in the event the patent is subsequently found to be valid and infringed. I

shall work with a legal rule that awards lost profits to the patentee.[39] Denote by p_M the patentee's profits in the absence of competition from the challenger. If the patentee's (flow) profits during the interim period are p_1, then the (flow) damages due are $p_M - p_1$.[40]

To illustrate these points, I now derive the Bertrand and Cournot equilibria when the challenger faces potential liability for infringing. I believe that this analysis is of independent interest as it characterizes price and quantity competition in the face of uncertainty about liability for infringement.

Bertrand Pricing Game Between Patent Holder and Challenger

Consider the case of homogeneous goods and Bertrand competition, perhaps better thought of as bidding competition to serve the market (or a single customer). As is often the case, Bertrand equilibrium with homogeneous products is quite a fragile concept. Denote by $p_i(p)$ the profits to firm *i* from winning at price p. If the two firms are equally efficient, $p_1(p) = p_2(p)$.

I now show that an equally efficient challenger will simply not enter the market under these conditions. Indeed, the entrant must be much more efficient than the incumbent to make entry profitable. As a consequence, even a weak patent can yield monopoly profits. This is a new twist on the well-known fact that an entrant with even a very small fixed cost of entry will not enter just to compete on price against an equally efficient rival. Here, there is effectively a fixed cost of entry, namely the expected liability costs of participating in the market.

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[39] I am assuming here that damages equal to lost profits, not a multiple of lost profits. In the case of willful infringement, damages can equal three times the lost profits.

[40] Some very interesting questions regarding the treatment of mitigation in the calculation of damages are beyond the scope of this paper. If the patent holder could earn higher profits by adopting an alternative strategy in the face of infringement, i.e., if the patent holder does not do its best to mitigate damages, full lost profits may not be awarded. As a general principle, a damages rule that only award damages that could not be avoided has the property that the incumbent should ignore damages when setting its strategy during the interim period: damages are not influenced by the incumbent's *actual* strategy, but only by the lost profits under the incumbent's *optimal* strategy. By the same logic used below in the Cournot case, it can be shown in general that in a pure-strategy equilibrium, there is no difference between the rule that awards actual damages and the rule that awards the minimum possible damages (given the conduct of the infringing firm).

If the challenger enters the market and wins at price *p*, then the challenger's payoff is given by $p(p) - qp_M$, where p_M are monopoly profits. If the challenger enters the market, bids *p*, and loses to the incumbent who sets the lower price *q*, then the challenger's payoff is given by $-q(p_M - p(q))$.[41] Since the expected liability costs, qp_M, are independent of the entrant's bid, they do not influence bidding. Since $p(p) > qp(q)$ for values of *p* near to *q*, the challenger is always better off undercutting the incumbent rather than losing, for any value of *q* that exceeds marginal cost.[42] So, given the entrant's presence in the market, the only equilibrium is for both firms to bid down to marginal costs. Anticipating this outcome, an equally efficient challenger would not choose to enter the market in the first place.

If the challenger enjoys a sufficiently large cost advantage, entry may be profitable. In this case, the incumbent will bid down to the lowest cost at which it can break even, so the price satisfies $p_1(p) = 0$. Call this price p_1^*. The entrant captures profits of $p_2(p_1^*)$, but incurs expected liability costs of qp_M. The entrant must be sufficiently more efficient than the incumbent that the profits it can earn at the incumbent's break-even price cover these expected liability costs.

This analysis gives quite a strong, even striking result: the patent holder can capture the full monopoly profits, even if the patent is very weak. Here, a key question is whether the potential entrant can bid for business without exposing itself to liability in the event that the incumbent meets or beats the entrant's prices and thus wins the bidding. But this seems even harder to do than the corresponding strategy in the Bertrand pricing game with a fixed entry cost, where the entrant may be able to adopt a bidding strategy that allows it to avoid incurring the fixed entry costs if it loses the bidding. Here, if the entrant's bid induces a response from the incumbent, liability for infringement will be hard to avoid.

Proposition #5, *Pricing Competition in the Shadow of Liability:* Suppose the patent liability rule awards lost profits, and the two equally efficient firms compete as Bertrand rivals.

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[41] Here I am assuming damages equal to actual lost profits. The result would not change if damages were equal to the minimum possible lost profits given the entrant's price *p*, namely $p_M - p(p)$.

Then the challenger will not enter the market, and the patent holder will capture the monopoly profits, even if the patent is arbitrarily weak (q very small but still positive).

In this situation, since $PCI_L = 0$, consumers receive no benefits from interim competition and settlements look relatively attractive.

Output Game Between Patent Holder and Challenger

In the corresponding Cournot game, the firms simultaneously set outputs, resulting in a price (and profits) during the interim period. Then, if the challenger is found to have infringed, the challenger owes damages to the patent holder equal to the difference between monopoly profits and the profits actually earned by the patent holder

More formally, if the output levels are x_1 and x_2, and if the maximum profits that the incumbent can earn facing output level x_2 by the entrant are given by $p_1^*(x_2) = \max_{x_1} p_1(x_1, x_2)$, then the infringement damages owed to the patent holder (if infringement is found) are given by $p_M - p_1^*(x_2)$. Note that this damages rule has the attractive property that it gives the incumbent the incentive to set output to maximize profits, ignoring damages, which are independent of x_1.[43] So, the incumbent operates using its normal Cournot best-response function.

However, the entrant's behavior is definitely influenced by the prospect of infringement damages (so long as $q > 0$). Given x_1, the entrant's expected profits are given by

$$V_2(x_2) = p_2(x_1, x_2) - q(p_M - p_1^*(x_2)).$$

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[42] With the damages rules less generous to the patent holder, where damages equal $p_M - p(p)$, the challenger still is better off undercutting the incumbent than losing the bidding.

[43] With Cournot competition, the patent holder's best-response function is the same if the damages rule specifies actual damages rather than just damages that could not have been avoided given the conduct of the infringing firm. Formally, if actual damages are awarded, given x_2, the patent holder maximizes $p_1(x_1, x_2) + q(p_M - p_1(x_1, x_2))$, which is the same as just maximizing $p_1(x_1, x_2)$ as the patent holder does under the stronger mitigation rules.

Using the envelope theorem, we know that $\frac{dp_1^*(x_2)}{dx_2} = \frac{\partial p_1(x_1^*, x_2)}{\partial x_2}$, so the first-order equation for x_2 is given by $\frac{\partial p_2(x_1^*, x_2)}{\partial x_2} + q\frac{\partial p_1(x_1^*, x_2)}{\partial x_2} = 0$. The usual equation for the incumbent's optimal output applies: $\frac{\partial p_1(x_1, x_2^*)}{\partial x_1} = 0$.

If we have linear demand, $D(p) = A - p$ and constant marginal production costs of c_1 and c_2, then the firms' output in the resulting Cournot equilibrium are given by $x_1^* = \frac{A - 2c_1 + c_2}{3 - q}$ and $x_2^* = \frac{A - 2c_2 + c_1 - q(A - c_1)}{3 - q}$, with total output of

$$x^* = \frac{2A - c_1 - c_2 - q(A - c_1)}{3 - q} \qquad (7)$$

Naturally, when the patent is very weak, so $q \approx 0$, we get back the standard Cournot equilibrium. When the patent is strong, so $q \approx 1$, the challenger only produces if it is more efficient that the patent holder $(c_2 < c_1)$. If the challenger is not more efficient, equation (7) gives us back the monopoly output level of the patent holder; if the challenger is more efficient, we get the monopoly output level of the challenger. Effectively, the challenger maximizes profits for its lower level of costs and then compensates the patent holder for its own (lower) level of monopoly profits. This is one of many cases in which infringement by a more efficient firm is optimal so long as damages are equal to lost profits, not a multiple of lost profits (as in fact can occur for willful infringement).

Focusing now on the case in which the two firms are equally efficient, so $c_1 = c_2 = c$, the interim output level is given by $x^* = \frac{2 - q}{3 - q}(A - c)$. As q ranges from zero to one, output ranges from $\frac{2}{3}(A - c)$, the Cournot output level, down to $\frac{1}{2}(A - c)$, the monopoly output level. Since

consumer surplus as a function of output is $x^2/2$, consumer surplus generated by competition in the shadow of liability varies with patent strength according to $S_L(q) = \frac{(A-c)^2}{2}\left(\frac{2-q}{3-q}\right)^2$.

For any level of patent strength, expected consumer surplus is higher under interim competition than it will be (on average) following the resolution of the patent dispute. Expected consumer surplus after resolution of the dispute equals $(A-c)^2(\frac{q}{8}+\frac{2(1-q)}{9})$, since surplus under monopoly is $(A-c)^2/8$ and surplus under Cournot competition is $2(A-c)^2/9$. Comparing these functions, we find for all values of q between zero and one, consumer surplus is higher under interim competition than it will be on average after the resolution of the patent dispute.

The Patent Competition Index during the period when the firms are competing in the shadow of possible liability, PCI_L, is not difficult to compute in this case: $PCI_L = \frac{9}{7}(4(\frac{2-q}{3-q})^2 - 1)$. Of course, the index varies from one, when $q = 0$, down to zero, when $q = 1$. But note that PCI_L is concave, not linear, in q, and thus exceeds the probability of non-infringement, $1-q$, for all interior values of q.

Proposition #6, *Competition in the Shadow of Liability:* Suppose the patent liability rule awards lost profits, and the two equally efficient firms compete as Cournot rivals. Then competition prior to the determination of infringement yields *greater* benefits to consumers than will arise on average after the determination of infringement.

For example, when $q = 1/2$, we get $PCI = 0.57$. A patent with a 50% chance of winning generates more than 50% of the benefits to consumers from full-fledged duopoly. The extra benefits consumers get on average from interim competition, in comparison with subsequent competition, are greatest when infringement is very much in doubt, i.e., when q is in the neighborhood of one-half.

Proposition #6 tells us that the overall Patent Competition Index, calculated above to be $T * PCI_L + (1-T)(1-q)$, is increasing in the time it takes for the patent litigation to be resolved,

T, since the $PCI_L > 1-q$. This is very different from the Bertrand pricing case, in which $PCI_L = 0$ so consumers benefit from an earlier resolution of the patent litigation.

5. Settlements Specifying A Date of Entry

One way in which a patent and a challenger engaged in a patent dispute can settle their dispute is to negotiate a date at which the challenger can enter the market. Settlements of this type between incumbent patent holders selling branded drugs and potential entrants offering generic versions of these same drugs have been intensively scrutinized by the Federal Trade Commission.[44] These settlements have the unique feature that, under the Hatch-Waxman Act, settling with the first generic challenger can protect an incumbent drug company from other generic challengers as well for a specified period of time, because the first generic challenger may enjoy exclusive rights for a period of time. The FTC has expressed great skepticism regarding settlements in which the incumbent makes payments to the challenger as part of a negotiated entry date.

To keep things simple, let us suppose again that there are only two outcomes of the patent litigation: the patent is valid and infringed with probability q, or the patent is valid but not infringed with probability $1-q$.[45]

As above, call the date of the settlement time $t=0$, the expiration of the patent date $t=1$, and denote by T the date at which the entrant could enter if successful in the patent litigation. Restricting attention to settlements simply involving an entry date (but no royalties), it is easy to see which settlements leave consumers whole.

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[44] In March 2000, the FTC challenged settlements between Abbott and Geneva, http://www.ftc.gov/os/2000/03/abbottcmp.htm, and between Hoechst Marion Roussel (now Aventis) and Andrx, http://www.ftc.gov/os/2000/03/hoechstandrxcomplaint.htm. In April 2001, the FTC challenged settlements between Schering-Plough and Upsher-Smith and American Home Products, http://www.ftc.gov/os/2001/04/scheringpart3cmp.pdf. The FTC has also launched an industrywide study of such agreements.

[45] More complex cases with patent invalidity or various costs of inventing around the patent could be handled similarly.

Absent any settlement, expected consumer surplus is $\bar{S} = TS_M + (1-T)(qS_M + (1-q)S_D)$, where S_D again is consumer surplus under duopoly. Consumers benefit from a negotiated entry date *t* if and only $t < T + q(1-T)$. Assuming that duopoly profits are less than monopoly profits, however, there is little reason to expect the firms to find such entry dates mutually attractive. If the firms are risk neutral, a reasonable assumption for large, publicly-traded firms if not individual managers at those firms, and ignoring litigation costs, there simply are no gains from settlement under these conditions when the only available instrument is the entry date. Factoring in litigation costs, there will typically be a range of mutually acceptable dates in the neighborhood of $T + q(1-T)$. To the extent that the patent holder believes the patent is stronger than does the challenger, settlement is made even more difficult, as the patent holder will insist on a later entry date and the challenger not agree to wait so long to enter.

In this simple model, a naked cash payment flowing from the patent holder to the challenger (in excess of avoided litigation costs) is a clear signal that the settlement is likely to be anti-competitive. Presumably, the patent holder would not pay more than avoided litigation costs unless it believed that it was buying later entry than it expects to face through the litigation alternative. For this reason, the FTC has a sound basis for its skepticism regarding "reverse cash payments" from the patent holder to the challenger. This is not to say that such payments are necessarily anti-competitive if other factors are brought into the analysis, such as risk aversion and asymmetric information about market conditions, as "reverse cash payments" may be important in more complex settings for successful settlement.

Some of the settlements challenged by the FTC also involved the transfer of non-cash assets from the challenger to the patent holder. These side deals pose some additional, interesting questions. If the non-cash assets have a well-defined market value, then they can be treated much like cash. The proper test then involves comparing the *net* payment from the challenger to the patent holder to avoided litigation costs. A large net payment running from the patent holder to the challenger is inherently suspicious. A net payment running from the challenger to the patent holder should be quite welcome to antitrust officials, although it raises a tricky question: presumably, the challenger is paying for earlier entry than would occur (on average) from litigation, but if this is the case, why is it mutually profitable for the firms to agree to earlier

entry if entry dissipates joint profits? One benign answer is that joint profits *rise* with entry because the challenger brings complementary assets to the market or because the entrant earns more profits by taking business from *other* firms than it reduces the incumbent's profits.

If the non-cash assets received by the patent holder have no well-defined market value, it becomes necessary to estimate their value to the patent holder. If the patent holder is receiving more in value, as seen through its own eyes, than it is giving up, the patent holder is making no net payment to the challenger, and there is no basis for presuming that the settlement delays entry in comparison with litigation.

6. Patent Pools

Patent pools are another form of settling patent disputes. Famous patent pools over the years include the pool of sewing machine patents in the mid-19th century and the pool of airplane patents during World War I.[46]

The recent pool involving patents for laser eye surgery, which was forced to dissolve by the FTC, illustrates the general pattern. Each of the two companies forming the pool, Summit Technologies and VisX, claimed that it held patents essential to manufacture machines that perform laser eye surgery. Each sued the other for infringement. To settle their dispute, Summit and VisX placed their relevant patents into a pool, called Pillar Point Partners. The pool then licensed these patents as a package back to Summit and VisX as well as to third parties seeking to sell laser eye surgery machines. The pool charged $250 for each procedure performed using licensed machines. The FTC charged that "in the absence of the [pool], VisX and Summit could have and would have competed with one another in the sale or lease of … equipment by using their respective patents, licensing them, or both."[47] In contrast to this case, the DOJ issued

[46] See Klein (1997) for a nice discussion of the airplane patent pool.

[47] See the FTC's March 1998 complaint, available at http://www.ftc.gov/os/1998/9803/summit.cmp.htm. Summit and VisX later agreed to dissolve their patent pool. See http://www.ftc.gov/os/1998/9808/d09286ana.htm.

business review letters approving the pooling of patents necessary to make products complying with the MPEG standard and two standards for DVDs.[48]

Patent pools can easily be studied using the framework developed above. Suppose that firm #1 and firm #2 each holds a patent that it asserts is essential to the manufacture of a given product. If the firms are themselves manufacturers, as in the Summit/VisX case, the two firms will be suing each other. If the firms instead intend to license their patents to manufacturers, then both firms will be asserting their patents against these manufacturers. Either way, in the absence of some agreement we have a classic and inefficient situation involving Cournot complements.

In the absence of a settlement, suppose that litigation will be resolved, as above, at date *T*. Prior to that time, let us suppose that the firms will license their patents independently. This is the standard Cournot complements problem, yielding consumer surplus of S_C.

After the litigation is resolved, one or both patents may be declared invalid. If each patent has strength q, then we have effectively three possible outcomes. With probability q^2, both patents are valid and we presume that the companies would then be allowed to form a pool, leading to the monopoly outcome, with surplus S_M. With probability $2q(1-q)$, precisely one patent is valid, in which case we again get the monopoly outcome. With probability $(1-q)^2$, both patents are invalid, in which case we get the perfectly competitive outcome (either via Bertrand pricing between the two firms or through free entry of manufacturers), with consumer surplus S_I. We know in general that $S_I > S_M > S_C$.

Putting all of this together, consumer surplus from ongoing litigation is given by

$$\bar{S} = T * S_C + (1-T)(q^2 + 2q(1-q))S_M + (1-T)(1-q)^2 S_I .$$

The settlement to be evaluated is the formation of a patent pool. Under the terms of the pool, the two patents are licensed as a package for a specified royalty rate, *r*, with the license fees then

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[48] The 1997 MPEG case can be found at http://www.usdoj.gov/atr/public/press_releases/1997/1173.htm. The first DVD pool was approved in December 1998; see http://www.usdoj.gov/atr/public/press_releases/1998/2120.htm.

divided up between the two firms. With the patent pool, consumers receive surplus of $S_P(r)$. The pool is beneficial for consumers if $S_P(r) > \bar{S}$.

One question to ask is whether a pool that replicates the monopoly outcome is beneficial to consumers. This is certainly possible, since $S_M > S_C$. To focus on this question, suppose that monopoly provides a fraction m of the incremental benefits to consumers over Cournot complements, in comparison with perfect competition. In other words, $m_M \equiv \frac{S_M - S_C}{S_I - S_C}$. With this definition, it is not hard to show that the most profitable pool, i.e., the pool replicating the monopoly outcome, is beneficial to consumers if and only if

$$m_M > \frac{T}{T + (1-q)^2(1-T)}. \qquad (8)$$

Since competition can only arise after date *T*, and even then only occurs with probability $(1-q)^2$, the monopoly pool can easily raise consumer surplus, if monopoly offers even a modest increase in surplus relative to Cournot complements.

More generally, we can define $m(r) \equiv \frac{S(r) - S_C}{S_I - S_C}$. Then the maximum acceptable royalty rate is found by plugging $m(r)$ into equation (8). Since $m(0) = 1$, we know that a pool with a sufficiently low royalty rate will always be beneficial to consumers. But, as just noted, even a pool with the monopoly royalty rate can lead to higher consumer surplus than ongoing litigation, especially if the litigation will be protracted, so that *T* is large, or if the patents are strong.

Proposition #7, *Royalties Charged by Patent Pools with Two Members:* Even a patent pool that replicates the monopoly outcome can benefit consumers by replacing a Cournot complements outcome; equation (8) **is the necessary and sufficient condition for this to occur. More generally, putting** $m(r)$ **into equation** (8) **gives the maximum royalty rate that a pool can charge and still make consumers better off than ongoing litigation.**

The second DVD pool was approved in June 1999; http://www.usdoj.gov/atr/public/press_releases/1999/2484.htm. The DOJ insisted that only "essential" patents be included in these pools.

These same methods can also be used to evaluate the effects of pools with more than two members. The equations are necessarily more complex, as we need to keep track of consumer surplus if k out of n patents are found valid, for $k = 0,1,\mathbf{K},n$. But the same principle articulated in Proposition #7 applies to these larger pools: if litigation is protracted and/or the patents are reasonably strong, even a pool replicating the monopoly outcome can be favorable for consumers. When this condition is met, antitrust concerns about proposed patent pools should be greatly reduced.

7. Conclusions and Extensions

In this paper, I have proposed and explored the following simple antitrust rule governing settlements of intellectual property disputes: a settlement cannot lead to lower expected consumer surplus than would have arisen from ongoing litigation. I argue that this rule respects intellectual property rights while encouraging efficient settlements. Under extremely general conditions, there exists a settlement that leaves consumers better off and raises the joint profits of the two firms engaged in the dispute. I then apply this general test to a several types of settlements: mergers; agreements specifying the timing of entry; and patent pools.

While this paper has covered a lot of ground, there are many more unresolved issues and questions in this and related areas. I close by noting a few on these outstanding questions.

First, I have focused here on situations involving a single patent, or, in the case of patent pools, just two patents. In many patent disputes, at least one party has a whole portfolio of patents. It remains to be seen how the presence of multiple patents affects my analysis. This would have implications for the incentives of firms to assemble, or perhaps disassemble, patent portfolios. I conjecture that there are diminishing returns to the number of patents held by one party.[49]

Second, I have explicitly avoided introducing asymmetric information between the two parties to an intellectual property dispute. Asymmetric information, and resulting differences in beliefs, are important factors that make settlement difficult. Another rich area of exploration involves

marrying the analysis in this paper with the extensive literature on bargaining and signaling in the presence of asymmetric information. Risk aversion could also be included.

Finally, I have focused my attention on a single challenger to a patent, while recognizing that other potential competitors may benefit if a patent is held invalid or interpreted narrowly. Another valuable extension would be to explicitly model multiple challengers, recognizing that the patent holder may have an incentive to settle with the strongest challenger, hoping that weaker challengers would then settle on more favorable terms.

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[49] In fact, I am aware of a situation in which one firm spun off part of its patent portfolio so that the two entities, each controlling essential patents for certain applications, could separately seek royalties from licensees.

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