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Profit Neutrality in Licensing: The Boundary Between Antitrust Law and Patent Law

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We address the patent/antitrust conflict in licensing and develop three guiding principles for deciding acceptable terms of license. *Profit neutrality* holds that patent rewards should not depend on the rightholder's ability to work the patent himself. *Derived reward* holds that the patentholder's profits should be earned, if at all, from the social value created by the invention. *Minimalism* holds that licenses should not be more restrictive than necessary to achieve neutrality. We argue that these principles are economically sound and rationalize some key decisions of the twentieth century such as *General Electric* and *Line Material*.

1. Introduction

Patent law and antitrust concerns were born side by side. On the one hand, the Statute of Monopolies (1623) announced a general ban on monopolies "for the sole Buying, Selling, Making, Working, or Using of any Thing within this Realm. . . ." On the other hand, it created new

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monopolies as an incentive for inventions. The decision to treat the same legal concept—monopoly—as a crime in one case and a reward in the other presents unique problems for judges. "[B]ecause the patentee's authority is an island of permission in a sea of prohibition, there is no area at the edge of permission toward which the law is indifferent: what is not authorized is forbidden" (Baxter, 1966). Expanded antitrust enforcement during the twentieth century has made this problem increasingly acute.

Over the twentieth century, courts and commentators explored many different proposals for defining the boundary between intellectual property and antitrust law. The simplest approach, "inherency," resolves the issue by allowing one body of law to dominate the other in any conflict (Adelman and Juenger, 1975). Early in the twentieth century, patent law dominated so that restrictive licenses were generally upheld. As argued by Kaplow (1984), commentators during the 1960s urged a different version of inherency that would have made antitrust dominant. Although generally disfavored, inherency arguments are still being made (Gifford, 2002; Patterson, 2000).

The alternative to inherency is balancing. However, if antitrust and patent law have different objectives, it is not obvious how to strike a balance. For this reason, most commentators have advocated balancing according to a single, agreed-upon objective such as "wealth maximization" or "consumer welfare" (Bork, 1965, 1978; Bowman, 1973). But even with a single objective, there is no obvious calculation that courts should use to balance ex ante incentives against ex post deadweight loss. Almost all cases and commentators argue that courts should infer the correct balance from Congress's intent as codified in the patent laws.

There are many different ways to divine intent. Twentieth-century judges and scholars have offered a bewildering variety of schemes for balancing. In general, there are two schools. The earliest, which dates from the 1920s, seeks to develop clear per se rules that can be applied more or less mechanically. Courts following this tradition have approved restrictions on licensees' prices (*General Electric*, 1926), on choice of customers (*General Talking Pictures*, 1938; Schlicher, 2002), and on licensees' geographic markets (Hovenkamp, Janis, and Lemley, 2004). Over time, the Supreme Court seems to have lost confidence in the per se agenda. In fact, the Court came within one vote of overruling *General Electric* in 1948 and

again in 1965. Lower courts have also adopted exceptions,[1] to the point where many commentators argue that *General Electric* is a "vestige" that prudent practitioners should not rely on (Weinschel, 2000). Nevertheless, it remains the law of the land.

The second school, dominant since the 1940s, argues for a more flexible "rule-of-reason" standard.[2] Courts currently use rule of reason for a wide variety of license restrictions (Weinschel, 2000, section 2, p. 90). However, this program has yet to develop widely recognized principles or rules. At its worst, "rule of reason" can be little more than a label disguising "amorphous" and "freewheeling" standards (Adelman and Juenger, 1975). Since the 1980s, however, scholars have thought hard about the questions that any principled rule of reason must resolve.

Most commentators agree that current law is unsatisfactory. In the words of Chisum (2003), "[f]rom the decisions, it is clear that the courts lack a clear and general theory for resolving that inquiry. Thus, individual problems are resolved in a piecemeal fashion, and it is difficult to harmonize decisions in one area (such as price restrictions) with another (such as field of use restrictions)." This doctrinal confusion has practical consequences. Blue ribbon panels have complained since the 1950s that legal uncertainty deters patentees from licensing their inventions (*Hensley*, 1967).

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1. For example, *General Electric* may not apply to the unpatented product of a patented machine (Hovenkamp, Janis, and Lemley, 2004; Weinschel, 2000), to patentholders with multiple licensees (Hovenkamp, Janis, and Lemley, 2004; Weinschel, 2000), to patentholders who do not manufacture the patented item (Hovenkamp, Janis, and Lemley, 2004; *Royal Industries*, 1969; Schlicher, 2002), to licenses that are said to "predominantly benefit" licensees rather than the patentholder (*Ethyl*, 1940; Weinschel, 2000), to licenses where the patent does not "completely cover" the product (Hovenkamp, Janis, and Lemley, 2004; Schlicher, 2002), to patentholders who acquire their rights by purchase rather than internal R&D (Hovenkamp, Janis, and Lemley, 2004), or to intellectual property rights other than patents (Hovenkamp, Janis, and Lemley, 2004; *Interstate Circuit*, 1939).

2. Although we find it convenient to speak of per se and rule-of-reason approaches as completely distinct, the truth is considerably more complicated. The Supreme Court has warned that "there is often no bright line separating per se from Rule of Reason analysis" (*California Dental Assn.*, 1999). Judges who apply rule of reason must be guided by our general knowledge of economic theory (Areeda and Hovenkamp, 2003), and judges must be prepared to change per se rules, however reluctantly, as knowledge and experience accumulate (Areeda and Hovenkamps, 2003).

In this article, we take a fresh look at these issues, motivated mainly by *General Electric* and price restrictions, but also addressing the issues in *Line Material*. We start by stating three principles suggested—or at least consistent with—the case law and commentary that have developed over the past half century. As many courts have implicitly followed them, we think the principles have merit from a doctrinal point of view. Perhaps more importantly, we argue that they have merit from a welfare point of view, in addressing the patent/antitrust conflict. Needless to say, the motivating problem of price fixing does not exhaust the list of situations where antitrust and patent laws collide,[3] and our three principles may not be determinative in every instance. However, we show that they also apply to the leading cases that involve improvement patents.

Section 2 explains the three principles, gives their normative foundation, and says how they relate to case law and commentary. In section 3, we analyze the licensing of a product patent, as in *General Electric*, showing why price restrictions might be consistent with profit neutrality and minimalism. In section 4, we consider product enhancements or additives as in *Ethyl Gasoline* and *Line Material*. In section 5, we list three possible per se rules and analyze their strengths and weaknesses. In section 6, we compare rule of reason's strengths and weaknesses with a revived per se approach. Section 7 is a short conclusion.

To the extent that this article focuses on the conflict between efficient use of intellectual property, which provides market power, and the goal of competition, it raises many of the same issues as in the economics of vertical relationships (Rey and Tirole, 2006). What is added in this context is that market power is a proper consequence of intellectual property, and this must be added into the balance.

2. The Three Principles

By the 1920s, the Supreme Court had abandoned the inherency view that a patentholder could impose whatever license restrictions he

3. Prominent examples include tying, field of use and geographic restrictions, package licensing, post-expiration royalties, grant-back provisions, the first sale doctrine, restrictions on users' right to repair patented machines, settlement agreements, and agreements that extend rights beyond the scope of the antitrust laws.

desired. When the Court concluded that at least one license restriction (tying) violated the antitrust laws, they opened the door to questioning others. Which restrictions should be legal and which not? The *General Electric* opinion announced a new standard: to be lawful, license restrictions would have to be "reasonably adapted to secure pecuniary reward for the patentee's monopoly" (*General Electric*, 1926). As Kaplow (1984) remarks, most courts and commentators seem to believe that this phrase entitles the patentee to a "specific level of aggregate reward." In our view, however, a better and more plausible interpretation is that courts should ask whether the patentee's methods are reasonable while remaining agnostic about whether the amount of the reward is reasonable.

We argue that much of twentieth-century jurisprudence about licensing can be summarized in three principles and that these principles make sense from a normative point of view. They are *profit neutrality*, *derived reward*, and *minimalism*. Their normative merits, discussed below, take as given that intellectual property law is well designed to start with, but if not, the antitrust treatment of licensing is not a remedy.

Profit neutrality is our label for the principle that a patentholder's reward should not depend on whether he has the ability to work the patent efficiently himself. Profit neutrality codifies the principle that if an R&D idea is worth pursuing—if its benefits outweigh the R&D costs—then the decision to invest should not depend on extraneous accidents of history such as whether the potential inventor owns manufacturing facilities, is liquid, or has access to financing. Profit neutrality is particularly important in a research environment where "ideas are scarce" (Scotchmer, 2004), so that an innovator's inability to exploit his invention fully may cause the idea to be lost.

Courts implicitly embrace profit neutrality when they proclaim that "[a] patentee is generally entitled to determine how it wishes to commercialize its invention in order to optimize its economic benefit from the patent grant" (*Carborundum*, 1995). Commentators agree. Furth (1958) suggests the same principle when he argues that "price-fixing clauses should not enable the patentee and his licensees to acquire a greater total return or a greater power over the market than the patentee, assuming ability to exploit the patent fully himself could otherwise command." See also Baxter

(1966).[4] Still other commentators have stressed that licensing lets small independent inventors and businesses exploit their patents, discourages inefficient integration, and puts production in the hands of the most efficient manufacturer (Bowman, 1973; Landes and Posner, 2003).

Of course, to evaluate whether a given license term is required for profit neutrality, the court needs to assess the market consequences with and without the disputed term of license. This is a fallible process. The economic reasoning in *General Electric* was clearly inadequate. The Court paraphrased the rightholder's goals as, "Yes, you may make and sell articles under my patent, but not so as to destroy the profit that I wish to obtain by making them and selling them myself." As Bowman (1973) has remarked, "surely it is net receipts that should interest General Electric rather than the sheer accounting joy of attributing profits to its own manufacturing operations." Whether profit neutrality was in the Court's mind, the justices certainly lacked the economics modeling tools to implement it.

Derived reward is our label for the principle that the profit reward of the patent must be derived from the social value of the invention and that, if licensing increases the social value of the innovation, the patentholder is justified in profiting from the increase. In medieval times, sovereigns sometimes rewarded favorites by conferring monopolies in goods they did not invent. The danger of such a practice is that the reward can be much larger than the value created, causing investors to make inefficient investments. The Statute of Monopolies (1623) introduced a limitation: the state can only grant a monopoly in what was actually invented. The genius of this restriction is that the rightholder can never earn more than consumers are willing to pay for the patented invention. Our derived reward

4. "[I]t could be said, the economic value of the invention is best measured by the extent of restriction and profits that would attend direct patentee exploitation; and to prevent the patentee from capturing a part of these incremental profits by splitting them with licensees on whom he has conferred sheltered positions is to deprive the patentee of part of that value." Baxter ultimately rejects this argument on the ground that companies that held strong patents always prefer in-house production to licensing—that is, that profit neutrality cannot be achieved in practice through licensing. Although we do not dispute that there may be obstacles to perfect licensing, we nevertheless argue that profit neutrality is a legitimate goal and demonstrate terms of license that may be necessary to achieve it.

principle formalizes the principle that courts should look to the source of the reward (the social value of the invention) rather than size per se.

The derived-reward principle is also in keeping with United States (U.S.) law and legal scholarship. For example, we claim that the U.S. Supreme Court implicitly recognized derived reward when it held that a license cannot be used to create a monopoly on any product other than the invention itself (Schlicher, 2002) and that the patent monopoly should exclude "all that is not embraced in the invention" (*Morton Salt*, 1942). Indeed, the derived-reward principle is woven into the U.S. Constitution. Constitutionally, neither the Congress nor the courts has the power to give a patentee "more than the rewards of his discovery" (*Hensley*, 1967; see also *Line Material*, 1948 [Douglas concurring]). Commentators since the 1960s have uniformly argued that the patent reward should measure "the patented product's competitive superiority over substitutes" (Adelman and Juenger, 1975; Baxter, 1966; Bowman, 1973; Patterson, 2000). The derived-reward principle does this automatically. It also describes why any attempt to impose a reward on products not part of the patented invention—sham licensing—should be condemned.

Finally, *minimalism* is our label for the principle that licenses should contain no more restrictions than are necessary to achieve profit neutrality and derived reward. If it is possible to strike down license restrictions and still satisfy those two principles, courts should do so. Minimalism is rooted in the practicalities of antitrust enforcement and recognizes that superfluous restrictions are inherently dangerous.

However, despite the minimalism principle, we believe that judicial suspicion of contracts can be taken too far. We show in the next section how licensing can increase profit legitimately by increasing the efficiency of production. We therefore disagree with commentators who have argued that licensing can never improve efficiency over in-house production. The inevitable corollary to that point of view is that the real purpose of licenses must be to camouflage an illegal cartel, and licenses are therefore suspect (Neal Report, 1969). We know of no evidence for that view.

Of course, some licenses can still be shams. Even commentators who approve of licensing admit that it "substantially increase[s]" the danger that the parties will organize illegal cartels (Bowman, 1973). The *General Electric* rule, which offers immunity for price fixing, would be a

particularly handy way for conspirators to implement collusion disguised as legitimate licensing (*Ethyl*, 1940).

Courts and commentators have implicitly invoked minimalism to strike down license restrictions that seem superfluous. For example, *Shapiro* (1979) argues that the rightholder's power to restrict the sale of patented products should expire the first time a product is sold because "(t)he patentee can obtain the full reward of the patent in the first sale; a right to restrict the goods in more remote channels of trade is not a traditional part of the patent grant *nor is it needed in order for the patentee to fully enjoy the monopoly of the patent*" (emphasis supplied).

We do not, however, claim that our version of minimalism completely determines which terms of license should be allowed. Profit neutrality can be implemented by alternative contract terms, for example, output restrictions, price restrictions, and nonlinear royalties. To choose among them, courts will have to invoke principles beyond our model to say which restriction is truly minimal. The traditional suspicion of certain restrictions like price fixing will presumably bulk large in such an analysis.

In the next section, we investigate the problem of licensing a product patent, when the patentholder competes with a licensee. This is the case that the Supreme Court faced in *General Electric*, and also in *Line Material*, in a slightly different circumstance. Fixed fees and per-unit royalties cannot achieve efficient production or profit neutrality when the licensor and licensee compete and when marginal cost is increasing. Perhaps surprisingly, it is the licensor's output that must additionally be constrained, not the licensee's.

3. Licensing the Production of New Products

We start by considering product inventions, such as in *General Electric*. Using the notion of derived reward, we derive the natural meaning of benchmark profits for the purpose of defining profit neutrality and then discuss the terms of license that achieve the benchmark profit. In particular, we show that the price-setting clause in *General Electric* can be justified by profit neutrality, although other terms of license would also serve that purpose.

Since the invention opened a product market that otherwise would not exist, the value of the invention is the social value of the new product, out

of which the reward must be derived. Furthermore, the product must be produced efficiently to derive the full value. However, there are many reasons why the patentholder may not be situated to serve the whole market, such as being unable to raise the money for production or distribution facilities. Profit neutrality implies that licensing should mimic efficient in-house production.

We will let $\Gamma(q)$ represent the cost of producing q units of the product in a single plant. We assume that

$$\Gamma(q) = C + \int_0^q \gamma(\hat{q})\mathrm{d}\hat{q}$$

and that the marginal cost of production, γ, is given by a convex, positive, increasing function γ. We assume that, because of the setup cost C for each plant, efficient production requires a finite number of plants. For simplicity, we assume two. Our focus is on how production is distributed between the plants.

We suppose that the inverse demand curve (the willingness to pay for the marginal unit at quantity q) is defined by $p(q) = a - q$, where q is the total supply of all firms.[5] When two plants supply the market with quantities q_1, q_2, the market price will therefore be $p(q_1 + q_2) = a - (q_1 + q_2)$. The total available profit as a function of total output is

$$p(q)q - 2\Gamma\left(\frac{q}{2}\right). \tag{1}$$

The profit-maximizing total supply q^* and resulting price satisfy

$$q^* = \frac{1}{2}\left[a - \gamma(\frac{q^*}{2})\right] \tag{2}$$

5. The easiest interpretation is that each agent buys a fixed amount of the good in each period, which we shall understand as one unit. The potential buyers are indexed by their willingness to pay $\theta \in (0, 1)$. If agent θ buys the good at price p, her utility is $\theta - p$. If θ is uniformly distributed on the interval (0,1), the number of agents for whom $\theta - p > 0$ is $1 - p$. If q units of the good are supplied, the market-clearing price is $1 - q$, as that is the price that provides nonnegative utility to the q buyers with $\theta > 1 - q$ but negative utility to the others.

$$p(q^*) = \frac{1}{2}\left[a + \gamma(\frac{q^*}{2})\right], \tag{3}$$

and the resulting benchmark profit is $p(q^*)q^* - 2\Gamma(q^*/2)$.

The benchmark profit can also be achieved by licensing all production to two licensees, using fixed fees and fixed per-unit royalties. (Courts routinely approve fixed fees and royalties.) An explicit derivation of the required license terms can be found in our (2004) working paper, but the argument is easy to see from symmetry. If both firms are charged the same royalty, they face the same "marginal cost" and will produce the same output in equilibrium. The patentholder can control the price by controlling the royalty and can collect profits through the fixed fee. By wielding these two instruments, he can replicate the profit and production that is available if he controls the two production plants himself.[6]

However, we now argue that, if the patentholder operates one production facility and a licensee operates another under license, fixed per-unit royalties and fixed fees cannot achieve the benchmark level of profit. The patentholder will need additional license terms to achieve the benchmark profits.

In licensing the other supplier, the patentholder will need to use a positive per-unit royalty to keep the price up. But that makes the licensee's "effective" marginal cost (the resource cost γ plus the royalty) higher than that of the patentholder. Facing higher costs, the licensee will produce less. Hence, the marginal resource cost of the last unit produced by the licensee is less than the marginal cost of the last unit produced by the licensor, and production is inefficient. Resource costs could be saved by decreasing the licensor's production and increasing the licensee's production. Because the arrangement does not achieve productive efficiency, it cannot achieve the benchmark level of profits for the patentholder. This conclusion depends only on the hypothesis that, in equilibrium, the firm with higher "effective" marginal cost produces less. We formalize this argument in Proposition 1 in the Appendix, assuming that the patentholder and licensee are Cournot competitors.

6. A nuance is that the fixed fees might have to be negative, depending on the size of the setup costs.

The same problem can be stated in strategic terms. Suppose the patentholder and licensee are each producing $q^*/2$ units, as is efficient. Once the license agreement is in place, the patentholder can "exploit" the licensee by unilaterally increasing output. Such an increase reduces the market price and total profit but does not change the royalties and fixed fees paid by the licensee to the licensor. Much of the loss falls on the licensee. Licensors themselves will profit through increased sales and continued royalties, which outweigh their own loss in the market because of price erosion, provided the increase in supply is not too large.

The prospect of such ex post opportunism undermines the licensor's ex ante profit. The licensee will rationally predict that, after the license is signed, the licensor will supply more than $q^*/2$ units, and the market price will be lower than the profit-maximizing price. The terms that the licensee will accept at the outset will reflect this prediction. As a consequence, licensors cannot charge the fixed fees that they could charge if they could commit to producing only half the monopoly output, $q^*/2$. This is a subtle point that courts and commentators seem to have overlooked. For example, Bowman (1973) remarks that it "strains credulity" to think that *General Electric* would adopt a scheme "to restrain its own trade in patented lamps. . . ." In fact, this is exactly what *General Electric* must do to ensure profit neutrality.

The lesson here is that, to ensure efficient production, the licensor must find a way to restrict his *own* output rather than that of the licensee. He must find a way to commit against the opportunism described in the previous paragraphs. We now describe three ways to do this:

- Output restrictions: restrict the licensor's output.
- Price setting (as in *General Electric*).
- Nonlinear royalties: allow the royalty rate to decrease with the licensor's supply.

It is also worth noticing what will not work. It will not suffice for licensors to set a fixed price for the licensee without constraining their own price at the same time. We develop this point in Proposition 2 in the Appendix.

3.1. Output Restrictions

The easiest way for the licensor to commit against an opportunistic increase in supply is to cap his own output at $q^*/2$, as part of the license. Such a commitment improves the terms of license that the licensee will agree to, as the licensee is then guaranteed that the market price will be the monopoly price. Since the resulting license would be profit neutral with respect to the benchmark, we see nothing wrong with such a commitment. Courts have held that restricting the licensee's output does not pose an antitrust problem (Hovenkamp, Janis, and Lemley, 2004; Weinschel, 2000), but we are unaware of any case where restricting the licensor's output has been challenged.

3.2. Price Setting

The *General Electric* price-fixing exception allows the licensor to state a price for both the licensor and the licensee. The Supreme Court opinion says "the license in effect provided that the Westinghouse Company would follow prices and terms of sales from time to time fixed by the Electric Company and observed by it, and that the Westinghouse Company would, with regard to lamps manufactured by it under the license, adopt and maintain the same conditions of sale as observed by the Electric Company in the distribution of lamps manufactured by it." We therefore assume that the firms make their supply decisions after the royalty and fixed fees have been set, and after the licensor has stated the price.

We argue that the licensor can ensure the monopoly outcome by stating the monopoly price $p(q^*)$ and setting the royalty to be the difference between the monopoly price and the cost of the marginal unit when both firms are producing optimally:

$$\rho = p(q^*) - \gamma(\frac{q^*}{2}). \tag{4}$$

The fixed fee must be set so that the licensee's profit is zero if both firms produce $q^*/2$. If we can show that neither firm wants to deviate from $q^*/2$, then the licensor gets all the profit and production is efficient.

Consider first the licensee. The licensee cannot benefit by reducing supply below $q^*/2$. Since each of the inframarginal units provides him

with revenue (price) higher than the royalty plus marginal cost, reducing supply will cause him to lose net revenue. (Notice that if the price could increase, the licensee would typically want to reduce supply. A reduction would cause the price to increase on all the inframarginal units, whereas the loss on the marginal unit would be zero.) The licensee also cannot benefit by increasing supply above $q^*/2$. If the licensee increases supply, the market will have an excess supply at price $p(q^*)$. If the licensee does not manage to sell his marginal units, then he has wasted the cost of producing them. If he does sell them, he cannot cover costs, since the price is not higher than the royalty plus marginal cost of the incremental units. That is, $p(q^*) - [\rho + \gamma(q)] < p(q^*) - [\rho + \gamma(q^*/2)] = 0$ for $q > (q^*/2)$.

The licensor will also be content to supply $q^*/2$. Keeping the contractual price fixed at $p(q^*)$, reducing supply reduces profit, as $p(q^*) - \gamma(q) > 0$ for $q < (q^*/2)$. Suppose instead that he increases supply above $q^*/2$. As the price is fixed at $p(q^*)$, either the marginal unit crowds out a unit that would otherwise be sold by the licensee or the marginal unit is not sold at all. If not sold, it wastes the costs of production. If it crowds out a unit sold by the licensee, then the licensor loses the royalty ρ on that unit. But using equation (4) and the fact that $\gamma(\cdot)$ is increasing, it follows that $\rho > p(q^*) - \gamma(q)$ for $q > (q^*/2)$; hence, the licensor would rather collect the royalty from the licensee than to crowd out that unit and produce it himself.

This shows that with a royalty that satisfies equation (4) and price fixed at $p(q^*)$, there is an equilibrium with efficient production, even though the licensor competes with the licensee. The licensor can collect all the profit through fixed fees and royalties.

This analysis differs from that of Landes and Posner (2003) who argue that price fixing only serves "to increase the total costs of manufacture, to the detriment of the patentee qua patentee" or Baxter (1966) who argues that price and output restraints are counterproductive because they allow licensees to share in oligopoly profit. Licensors can recover profits by charging fixed fees as well as royalties.

3.3. Nonlinear Royalties

Suppose that, instead of imposing a fixed royalty, the licensor imposes a royalty rate ρ that falls with his own output, in particular, according to equation (5).

$$\rho(q_2) = p(q^*) - \gamma(\frac{q^*}{2}) - (q_2 - \frac{q^*}{2}). \tag{5}$$

Then $\rho(q^*/2)$ is the same as the royalty (4), but $\rho'(q_2) = -1$. It is intuitive that the licensor will restrict his output to avoid the fall in the royalty rate, and it is easy to verify that (5) represents the rate of decrease that sustains supply $q_2 = (q^*/2)$.

Of course, this scheme requires that the licensor send a royalty bill to the licensee based on the licensor's own output, which might create an enforcement nightmare for the licensee. The licensor will always want to argue that his supply was lower than it was, and the licensee will want to argue that it was higher.

Nonlinear royalties based on the licensee's supply are common, and at least two courts have said that such agreements do not violate the antitrust laws (*du Pont*, 1953; *Stockham Valves*, 1966). However, in the model presented here, royalties that increase or decrease with the licensee's supply will not lead to profit neutrality because they do not punish the licensor for trying to exploit the licensee once the terms of license are fixed. To punish the licensor for increasing supply beyond that to which he would like to commit, the royalty must vary with the licensor's supply, not the licensee's supply. Baxter (1966) has previously analyzed the role that sliding scale royalties play in partitioning the market between two licensees but did not consider the case where a patentholder/manufacturer is substituted for one of the licensees.

This is a good place to return to our inquiry about minimalism. The point of stipulating royalties that decline with the licensor's output is to soften the competition that the licensor provides to the licensee. It is even more direct to write license terms that restrict the licensor's supply. Many commentators believe, on somewhat slender case law, that U.S. law permits patentholders to impose minimum output levels on their licensees (Hovenkamp, Janis, and Lemley, 2004; Weinschel, 2000), but we know of no cases in which a licensor's commitment to self-restraint has been at issue.

The point we want to emphasize, however, is that the *General Electric* rule satisfies our three principles just as well as output restrictions and

nonlinear royalties do. Nevertheless, a court could overrule *General Electric* while retaining profit neutrality and derived reward, by arguing that one type of restriction—say, nonlinear royalties—was somehow more "minimal" than the other two. This extended version of minimalism would go beyond our analysis and presumably be based on a judgment that some restrictions facilitate illegal cartelization more readily than others. To implement it, a court might have to strike some *actual* contract restriction in favor of some *hypothetical* restriction.

4. Licensing the Production of Improved Products

The Supreme Court has also considered cases where the rightholder owns a technology for enhancing a preexisting product. We explore three cases. First, the underlying product may rely on public domain technology, in which case we will assume that it is competitively supplied. The Court considered such a case in *Ethyl Gasoline*, where the rightholder attempted to control the price of high-performance gasoline made with its patented additive. The Court struck down this license, arguing that the patentholder's right to control the additive's price did not extend to products made from it. Second, the enhancement may improve an underlying patented technology without infringing it. This may happen, for example, because a new entrant successfully invents around the original invention. Finally, the patented enhancement may infringe the underlying patented technology so that neither rightholder can practice the enhancement without the other's permission. The Court considered such "blocking patents" in *Line Material*, in which patents on the unimproved product (an electrical fuse) and its improvement prevented each firm from marketing the improved fuse without a license from the other. Once again, the Court struck down a price-fixing license, arguing that the *General Electric* rule should be limited to new products and not extend to enhancements to existing ones.

We will assume in what follows that each consumer's willingness to pay for the improved product is larger than for the original product by amount Δ. As before, we will suppose that the demand for the underlying good, say, unimproved gasoline, is given by $1 - p$, where p is the price, and that the inverse demand curve is therefore given by $p(q) = 1 - q$. We assume that the demand for improved gasoline at price p is $1 + \Delta - p$, and the inverse demand curve becomes $p(q; \Delta) = 1 + \Delta - q$. To be as clear as

possible, we will assume that the production costs for the two products are the same.

Profit neutrality holds that innovators should not be penalized for not being able to work the patent efficiently themselves. Just as for the case of product patents, the patentholder should be able to license for efficient production. However, where the new product enters as an improvement to an existing, patented product, the question arises whether licensing can be to the original patentholder. Licensing to the rival raises the specter of collusion.

Below we show that collusion is less a threat than it seems. We also use our principles to explain why licensing of blocking patents should be more permissive than licensing of noninfringing patents.

4.1. Patented Improvements to Unpatented Goods

If a patentholder is not liquidity constrained, he can supply the whole market with the improved product. Because of potential competition with the unimproved product, the patentee's price cannot exceed the (potential or actual) price of the unimproved product by more than Δ. However, if the potential competitors already own production plants, it is more efficient to license production to the potential competitors. Under the profit-neutrality principle, the patentholder should be able to license at a per-unit royalty of no more than Δ, and in fact, this outcome will be disciplined by the market. Minimalism holds that price fixing should not be permitted if this profit opportunity can be exploited with royalties alone. In *Ethyl Gasoline*, the Court struck down additional terms, because they believed the additional terms supported a sham license and therefore violated the derived-reward principle.

We now argue that a constant per-unit royalty is, in fact, sufficient to achieve the patentholder's proper, profit-neutral reward.

We assume that the underlying good is competitively supplied, that the resource cost of producing the enhancement is zero, and that the minimum average cost of producing the improved or unimproved product (which is equal to the marginal cost at the efficient scale of production) is $c < 1$. In a competitive market, the cost of the improved product will then be $p = c + \rho$ if ρ is the royalty. Assuming that the licensor charges the entire value as royalty, $\rho = \Delta$, the price of the product will go up by Δ, so that

sales of the improved product are the same as without the improvement. During the life of the patent, it is the patentholder rather than the user who collects the social value. This is consistent with the derived-reward and profit-neutrality principles.

If the improvement is large, $\Delta > 1 - c$, and the improver charges the monopoly price for the improved product, then competitive suppliers of the unimproved product will drop out of the market. Despite the monopoly price, consumers are better off than without the innovation. The price charged by the monopolist improver is nevertheless smaller than the value Δ created for them, and the outcome is therefore consistent with the derived-reward and profit-neutrality principles.[7] For small improvements, $\Delta < 1 - c$, the proprietor will have to license the competitive suppliers because they will not disappear. The licensor's best option is to charge a royalty equal to the full value of the additive, $\rho = \Delta$. No distributor would pay a larger royalty for the additive, and a smaller royalty yields less profit for the patentholder.

We conclude that in the case of patented enhancements to competitively supplied goods, and also in the case of cost reductions, which can be analyzed in the same way as product enhancements, royalties are a rich enough licensing instrument to collect profit from the value created. As long as the competitive suppliers are free to sell unimproved gasoline, the royalty will only be the value of the enhancement, Δ, and the price of improved product cannot be larger than $c + \Delta$.[8]

4.2. Noninfringing Improvements to Patented Goods

We now assume that both goods are patented, but that the improved good does not infringe the prior patent. Because the products are

7. The monopoly price of the improved product is larger than the competitive price of the unimproved product by $(1/2)(1 + \Delta + c) - c$, which is smaller than Δ when $\Delta > 1 - c$. Consumers prefer the improved product at the monopoly price to the unimproved product at the competitive price.

8. Of course the patentholder may try to support a cartel with "sham licensing" that uses hidden understandings to achieve a result beyond the plain text of the license. This could be done, for example, by combining a license that sets royalties higher than Δ with an unwritten understanding that the parties will not produce unimproved gasoline. Historically, courts have shown no hesitancy in finding that facially acceptable licenses were shams designed to cloak such a cartel. In any case, such an arrangement is difficult to sustain if there is free entry in the market for unimproved gasoline.

noninfringing, two firms have the right to be in the market. We would expect, and Congress apparently intended, that there would be rivalry between the two firms. Assuming that both firms operate without liquidity constraints and can build as many plants as necessary, this is the profit-neutral benchmark. Even if the improver ends up supplying the whole market efficiently in two or more plants, potential competition from the prior patentholders will constrain his supply.

However, the total social surplus is greater if both firms produce the improved product, and especially if they do so efficiently. Licensing can increase the total social surplus available, and by the derived-reward principle, the improver should be allowed to collect part of the increase as profit. The question is whether this social improvement can be achieved through licensing without creating a collusive situation in which the licensor collects more than the social surplus contributed by the invention. The essence of the discussion below is that, provided the original patentholder cannot commit against supplying the unimproved product, potential competition will limit the price of the improved product and also limit the improver's reward. However, there is also a limit to this good news. By allowing some productive inefficiency, the firms can reduce the attractiveness of the licensee introducing the unimproved product, and can thus support a higher price.

We begin by considering what happens in the profit-neutral benchmark where the firms compete without a license. Let p^u be the price of the unimproved good, and let p^e be the price of the improved good. If both goods are supplied, the equilibrium price of the inferior good must be smaller by the value of the improvement Δ, that is,

$$p^u = p^e - \Delta. \tag{6}$$

Thus, if both goods are supplied, it will hold that

$$p^e = (1 + \Delta) - (q_1 + q_2) \tag{7}$$

$$p^u = 1 - (q_1 + q_2), \tag{8}$$

where q_1 is firm 1's supply of the unimproved good, and q_2 is firm 2's supply of the improved good. Using these prices, the profit functions of firms 1 and 2 without licensing are given by

$$q_1[1 - (q_1 + q_2)] - \Gamma(q_1) \tag{9}$$

$$q_2[(1 + \Delta) - (q_1 + q_2)] - \Gamma(q_2). \tag{10}$$

To characterize this equilibrium, let $q^D(\Delta)$ be the duopoly supply when both firms supply the improved good (defined for each Δ). Then, in equilibrium, firm 1's supply will be greater than $q^D(0)$, and firm 2's supply will be less than $q^D(\Delta)$.[9]

This outcome is inefficient in two senses that could be remedied by licensing. It is inefficient in the sense that some consumers buy the unimproved good, and it is also productively inefficient when marginal cost is increasing, since $q_1 < q_2$.

Consider first a license that specifies a constant royalty ρ and perhaps fixed fees. The royalty must satisfy $\rho = \Delta$. Firm 1 would not accept a greater royalty (it would supply the unimproved good instead), and firm 2 would not offer a smaller royalty, as a smaller royalty would result in a lower market price and less total profit. (We assume here that the license is designed to maximize joint profit, as the profit can be divided by fixed fees.[10]) It is because the royalty is constrained to satisfy $\rho \leq \Delta$ that licensing cannot cartelize the market.

With licensing, the licensee's profit function is given by (11), and q_1 represents a supply of improved product:

9. We are implicitly assuming here that only one plant produces each good. More plants would introduce more fixed costs, and we are implicitly assuming it is not worth it. The duopoly supply of firm 2 satisfies $q_2 = (1/2)[1 + \Delta - q_1 - \gamma(q_2)]$, and the duopoly supply of firm 1 satisfies $q_1 = (1/2)[1 - q_2 - \gamma(q_1)]$. If both firms supplied the improved good, the duopoly supply would be $q^D(\Delta) = (1/3)[1 + \Delta - \gamma[q^D(\Delta)]]$ for each Δ including $\Delta = 0$.

10. As we want to focus on whether the royalty can be used for collusion, we ignore the subtlety that there may be a constraint on fixed fees, namely, to be positive. Embedded in the assumption that the licensor cares only about total profit is the notion that fixed fees can be positive or negative, as necessary to divide the profit to reflect bargaining positions.

$$q_1[(1+\Delta)-(q_1+q_2)-\rho]-\Gamma(q_1). \tag{11}$$

Because equations (9) and (11) coincide when $\rho = \Delta$, both firms have the same profit functions with and without licensing, and hence the same equilibrium supplies (q_1, q_2). With licensing, q_1 represents the improved good, which eliminates the inefficient consumption of the unimproved good, but does not eliminate productive inefficiency, as the royalty elevates the licensee's "effective" marginal cost (including the royalty) above that of the licensor.

We now ask whether price or quantity restrictions can solve the problem of productive inefficiency. Are there licensing instruments that allow the firms to take advantage of the original patentholder's production facility while ensuring that all consumers are served with the better product and also preserving rivalry and productive efficiency?

The instruments we have previously considered are price-fixing and quantity restrictions. Although these seem like natural instruments for collusion, we argue in Propositions 3 and 4 in the Appendix that, for relatively small improvements, potential competition will limit the price of the improved product, regardless of the licensing terms. For large improvements, the improved product drives out the unimproved product, even with monopoly pricing and no licensing.

When the improvement is relatively small, the profit-neutral benchmark involves productive inefficiency. One might have imagined that *General Electric* style price fixing could once again be used to support efficient production. However, Proposition 3 tells us that price fixing cannot lead to smaller supply than the duopoly output and thus cannot improve on a license that only has fixed fees. This is because the fixed-price license fixes the price of the licensor as well as the licensee and thus encourages the licensee to undermine the price by also supplying the unimproved product. As that type of price-fixing clause will not accomplish the desired goal, the Court is justified in striking it down on the basis of minimalism.

Quantity constraints may be a better option, but for small improvements, Proposition 4 tells us that the price is still kept in check by the threat of entry. If the quantities supported by the license are efficient

(equal), they cannot be lower than those supplied by a duopoly where both firms supply the unimproved product. But, in any case, the profit-maximizing license will not support efficient production. Proposition 5 says that, starting from a situation of efficient production, total profit can be increased by reducing the licensor's own output and increasing that of the licensee, so that the licensee has less incentive to supply the unimproved product in parallel.

We have focused on licenses that fix both the licensee's and licensor's price because that is the type of license considered in *General Electric*. However, in Proposition 6 and Example 1 in the Appendix, we consider licenses that fix only the price of the licensee. Such a license can only support efficient production for relatively large improvements and with total supply that is bounded below, again, by duopoly supply. However, the firms can again increase profit by introducing an inefficiency of a different kind. Namely, they can implement a kind of price discrimination by forcing the licensee to sell at a high price, whereas the licensor sells at a low price.[11]

The thrust of these arguments is that when the patented products are noninfringing, and where one product clearly dominates its predecessor, it is difficult to mediate the conflict between ensuring rivalry and supporting efficiency. To ensure rivalry, the patents should not be consolidated in the hands of one owner with exclusive licensing, and the owner of the original patent should not be allowed to renounce his right to produce the original product. To ensure efficiency, both firms should produce the better product, which requires licensing. But then the firms have an incentive to favor the owner of the original patent in the licensing agreement (assuming that they can divide total profit by fixed fees), to reduce his temptation to introduce the unimproved product in parallel. This may lead to productive inefficiency.

4.3. Blocking Patents

We continue with the same model, but now assume that the improved product infringes the patent on the original product so that the

11. When the firms sell at different prices, the outcome in the market depends on which consumers end up in the favored position of buying at the lower price. The results about price fixing depend on a "rationing rule" that describes our assumption about this. Different rationing rules would give different outcomes in the market, and none is entirely defensible.

patent holders have blocking patents. Unlike the cases discussed above, licensing cannot be avoided if the improved product is to come to market. With or without liquidity constraints, the improver's market outcome without licensing is to earn zero profit. In light of this apparent mandate for licensing, courts have struggled for the past sixty years to set bounds on what types of licenses are allowable. In general, the question is whether the parties should share a full monopoly reward.

In *Line Material* (1948), the U.S. Supreme Court resisted such a solution, in particular, holding that price fixing should not be extended from the circumstances of *General Electric* to blocking patents, because that would reduce "[t]he stimulus to seek competitive [*i.e.*, noninfringing] inventions." Although the Court's discussion is elliptical, the Court seems to assume that inventors have a choice between creating an infringing or noninfringing improvement; that noninfringing improvements are to be encouraged because they lead to duopoly competition; and that patent law ought not to reward an innovator for making a strategic choice to create an infringing improvement when a noninfringing improvement is possible. However, the Court's assumption that the inventor faces a strategic choice whether to infringe is unrealistic if the underlying patent is broad. If broad, infringement is inevitable.

In our discussion of noninfringing improvements above, we only considered one-way royalties because there is no justification under the derived-reward principle for letting the first innovator profit from the incremental value of the improvement. We showed that one-way royalties, and one-way licenses more generally, will not lead to monopoly pricing of the improved product, because of the first patentholder's ability to supply the unimproved product in parallel.

In contrast, bringing an infringing improvement to market requires two-way licensing, which introduces the possibility of supporting the monopoly price. Suppose, for example, that the cross license on the improved good provides for cross royalties (ρ_1, ρ_2), with firm 2 paying a royalty ρ_2 and firm 1 paying a royalty ρ_1, each to the other firm. Higher royalties will lead to a higher market price for the improved good. In fact, we show in Proposition 7 that if the marginal cost function can be written $\gamma(q) = bq$, the total market supply depends only on the sum of the royalties, $\rho_1 + \rho_2$, and is an increasing function of $\rho_1 + \rho_2$. If the royalties can

satisfy equation (12) without also calling forth a supply of the improved product, the cross license will support the monopoly price

$$\rho_1 + \rho_2 = \frac{2}{4+b}(1+\Delta). \tag{12}$$

Thus, cross licensing with cross royalties can undermine the *Line Material* agenda of preserving competition.

However, the royalties must also satisfy (13), as otherwise the first patentholder would supply the unimproved product instead.

$$\rho_1 \leq \Delta. \tag{13}$$

But Proposition 7 shows that if $\rho_1 < \rho_2$, firm 1 will choose a larger supply than firm 2, and production will be inefficient. If it is impossible to satisfy equations (12) and (13) together with $\rho_1 = \rho_2$, there is a conflict between productive efficiency and supporting the monopoly price. Licensing to mitigate the productive inefficiency will lead to lower royalties and a lower price than the monopoly price. Thus, the constraint (13) creates price benefits for users that are similar to those created by direct competition between the firms, even though the constraint is due to *potential* competition from the unimproved product. Moreover, the downward pressure on price is present even if the firms use quantity constraints or price fixing, provided they do not use a covenant against the manufacture and sale of the unimproved good. Without such a covenant, two-way price fixing will not improve the firms' joint profit, by Proposition 3. According to our minimalism principle, the *Line Material* Court was therefore justified in striking it down. It serves no legitimate purpose that is unattainable by other means, and might disguise a sham.

In *Line Material*, the Court does not address the possibility that it is impossible for an improver to invent around the underlying patent, for example, because the underlying patent is very broad. In that case, infringement is inevitable rather than strategic. We adopt the conceit that, as a matter of patent law, the prior patent is that broad (infringement is inevitable) only if there is no alternative path to the improved product. The value of the improvement should then be counted as part of the social

value provided by the first innovator (Scotchmer, 1991). Because he created the option on the improved product, the first inventor is as responsible for the improved product as the improver. Using the derived-reward principle, the first inventor should be allowed to collect any fraction of the social value embodied in the combined innovations, and the improver should be allowed to collect any fraction of the incremental social value of the improvement. Monopoly pricing of the improved product is no more offensive to competition policy than if a single inventor had developed the enhanced product in the first instance without any intermediate step.

The problem then becomes how to support the monopoly price. Because neither firm can market the improved product without a license, the problem should be easier than when the products are noninfringing. However, providing for efficient production is harder than one might think. Suppose, for example, that one patentholder sells his patent to the other patentholder. (This would be presumably be prohibited by the *Line Material* Court, under their assumption that infringement is strategic rather than inevitable.) The owner of both patents is then a monopolist, and the improved product has a market position similar to the patented product analyzed in section 3. We uncovered three methods to ensure productive efficiency: by fixing the price of both firms, by using quantity constraints, or by imposing a nonlinear royalty.

These methods only work, however, if the unimproved product can be kept off the market. Propositions 3 and 4 show that it is difficult to support the monopoly price if one of the parties has the option to revert to the unimproved product.[12] To avoid that, the license could prohibit sales of the unimproved good explicitly. Such a provision would be offensive to competition policy in the case of noninfringing patents, but is less offensive here, because of our argument that licensing should support the monopoly profit. Nevertheless, it would be better to achieve the result (monoply pricing and efficient production) with more traditional instruments. The

12. To make this story even more complicated, if users have different willingness to pay for the quality improvement, as in the case considered by O'Donoghue, Scotchmer, and Thisse (1998), then the monopolist might want to supply both products as a means of price discrimination.

problem, as we have seen, is that cross licensing with cross royalties can only support the monopoly price at the cost of productive efficiency.

5. Possible per se Rules

Antitrust law, famously, requires courts to analyze some practices de novo ("rule of reason") while allowing courts to condemn others using shorthand rules of thumb ("per se rules"). Deciding which rules should govern in any particular situation is subtle. With perfect judicial reasoning, rule of reason would always be preferable to per se rules. The great advantage of per se rules is that they save courts the trouble of recapitulating economic analysis for each case. Over the past seventy-five years, courts and commentators have reached an impressive degree of unanimity on many questions—but only at the cost of innumerable missteps and misconceptions along the way. Codifying this learning in clear, per se rules, allows judges and lawyers who are new to the subject—always the great majority—to avoid old errors and misunderstandings.

The dichotomy between rule of reason and per se rules is both real and useful. However, it is easily overstated. As Judge Bork remarked almost forty years ago, "The current shibboleth of per se illegality in existing law conveys a sense of certainty, even of automaticity, which is delusive ... Alongside cases announcing a sweeping per se formulation of the law there has always existed a line of cases refusing to apply it" (Bork, 1965).[13] Commentators attempting to disentangle patent and antitrust law have traditionally recognized this flexibility by simultaneously proposing per se rules and recognizing the evidentiary showing that would be needed to rebut them (Adelman and Juenger, 1975; Baxter, 1966; Landes and Posner, 2003). We adopt this strategy in what follows.

This section suggests several possible per se rules that follow from the three principles, discusses some of their advantages and disadvantages, and points out which ones are firmly established in law and practice. Where the presumption in favor of these rules can be rebutted, we think the rules that replace them should use the three principles as a guide.

13. The point remains equally valid today: "In fact, the per se rule is not so tightly prohibitive and the rule of reason not so hospitable to a claim as is often thought" (Areeda and Hovencamp, 2003).

1. Patent licenses based on a combination of fixed fees and constant per-unit royalties should be presumed lawful.
2. In a market where the patentholder does not compete with potential licensees, licenses that (a) fix product prices for the licensee and licensor, (b) require the licensee or licensor to observe quantity limits, or (c) reduce the licensee's per-unit royalties as licensor output increases should be presumed lawful.
3. In a market with noninfringing patents, combining ownership of the patents, or writing a covenant to prohibit the sale of one of the patented products, should be presumed unlawful.
4. In a market with a patented product where noninfringing entry with another patented product is possible, a covenant to restrict the sale of either product should be deemed unlawful.
5. In a market with a patented product where noninfringing entry is *im*possible, a covenant to restrict sale of the patented product should be deemed lawful.

Rule 2, following the analysis in section 3, endorses three equivalent tools for achieving the patentholder's profit-neutral reward. Rule 2(a) (price fixing) is the *General Electric* rule. Rules 4 and 5 address the case where an improver enters the market, resulting in blocking patents, as otherwise there is little reason to restrict sale of the patented product. Rule 4 says that the firms with blocking patents should not be allowed to avoid potential competition when it would have been possible to invent around the first patent. This implements the *Line Material* Court's suggestion that inventors not receive a greater reward for creating inventions that infringe than for creating ones that do not infringe. Rule 5 says that, where inventing around is impossible, it is consistent with our principles to let the firms avoid potential competition to achieve the monopoly outcome. Rule 5 limits *Line Material* to the case where inventing around is possible.

These rules would reduce but not eliminate uncertainty for licensors. First, they establish presumptions, as do most per se rules created by courts (Areeda and Hovenkamp, 2003) and commentators (Adelman and Juenger, 1975; Baxter, 1966; Kaplow, 1984), but presumptions can be challenged. Judicial suspiciousness of licensing has, in fact, fluctuated. In an earlier era, when licensing was seen as an inferior way to exploit a patent, judges were always on the lookout for sham licensing

(Adelman and Juenger, 1975; Baxter, 1966). The modern view, reflected here, is less suspicious and operates from a presumption that licenses are pro-competitive in the absence of evidence that royalties exceed the value of the defendant's invention or other departures from our principles that clearly point to collusion.

Second, some of our conclusions follow from a standard, but nevertheless specific, economic model about how licensors and licensees behave–they compete on quantity. However, the principles and intuition are more robust than that model. Productive inefficiency arises with one-way royalties because the licensor perceives a lower marginal cost of production than the licensee and will produce too much relative to the licensee. It is hard to see how any form of competition between the licensor and the licensee would change this conclusion as long as marginal cost is increasing. In any case, per se rules can be rebutted with new and convincing arguments. A successful rebuttal would have to include (1) a model where the effect vanishes and (2) evidence that the model is more appropriate to the facts than the very standard model discussed in this article.

Third, more complicated economic environments might call for different rules. For example, when firms cannot observe cost or demand conditions, it is difficult to use licensing for efficiency, and when courts are burdened by the same lack of information, they may find it difficult to detect shams (Adelman and Juenger, 1975; Landes and Posner, 2003). At the same time, courts' inability to find all the relevant facts is a traditional justification for having per se rules in the first place (Areeda and Hovenkamp, 2003). These competing arguments cannot be evaluated without evidence and economic modeling, and we propose our three principles as an evaluative lens.

Fourth, our focus on productive efficiency does not exhaust the licensing landscape. Some commentators argue that licensing undermines the incentive to challenge a bad patent, as it creates collusion between otherwise competitors (Adelman and Juenger, 1975; Hovenkamp, Janis, and Lemley, 2004; Landes and Posner, 2003; Shapiro, 2003). This argument is not actually about the patent/antitrust boundary, as it goes to the proper functioning of the patent system itself. Scholars also argue that cross licensing should be permitted in cases where it is needed to save transaction costs or suppress wasteful patent races (Landes and Posner, 2003). However, the

firms' private incentive to avoid a patent race does not generally accord with what is socially efficient (Scotchmer, 2004, chapter 6).

Fifth, although the minimalism principle would allow courts to strike down unnecessary restrictions in licenses, it says nothing about whether some other, completely different, bundle of restrictions would impose even fewer burdens on the economy. It is difficult for judges to compare licensing terms against alternatives not before the court (Kaplow, 1984).

6. Rule of Reason

The previous section suggested how our principles could be embodied in per se rules. The first and third rules are mostly uncontroversial. The second acknowledges that, if patentholders are liquidity constrained, they may need terms of license beyond a constant per-unit royalty to collect their just reward. The fourth extends the implicit agenda of *Line Material* by preserving some measure of competitive pressure where an infringing improver, by hypothesis, could have chosen a noninfringing improvement. The fifth embodies the idea that licensing privileges should be more liberal if the underlying patent is broad enough to be uncircumventable.

Our principles could alternatively be understood as considerations in a rule-of-reason analysis. However, rule of reason is seldom based on a complete, well-articulated principle.[14] The most ambitious attempt to enunciate principles is due to Kaplow (1984). He argues that Congress implicitly encoded its judgment about the optimal balance of ex ante and ex post efficiency when it designed the patent statute. A licensing restriction should be acceptable to the court if it generates a profit-to-deadweight-loss ratio larger than that which Congress implicitly accepted in defining, for example, breadth or patent life. This procedure saves the court from having to decide how much reward an innovator should

14. For example, the U.S. Department of Justice and Federal Trade Commission says that the benefits of allowing the licensor "to exploit its [intellectual] property as efficiently and effectively as possible" must outweigh the harm to competition (1995 *Antitrust Guidelines*). The problem with this approach is that it fails to specify how courts should balance ex post deadweight loss against ex ante incentives to innovate.

receive, at least directly. The optimal reward is implicitly established in the profit-to-deadweight-loss ratio.[15]

Kaplow concedes that any practical application of the ratio test is "quite complex." Given that the required information "will not generally be available," court decisions "must inevitably be speculative."[16] He concludes that "any careful attempt to resolve patent-antitrust issues will be far more complex than has previously been realized" and that fact reveals the "insufficiency of prior formulations by courts and commentators." Scholars in the past twenty years have done little to change this assessment.

Any rule-of-reason approach directed at maximizing an aggregate measure of consumer welfare will face the same practical and theoretical difficulties identified by Kaplow. Given Kaplow's pessimistic forecast as to whether the ratio test can be implemented, the more likely approach seems that implied by the 1995 *Antitrust Guidelines*, requiring judges to weigh de novo the value of rewards (ex ante efficiency) against the value of competition (ex post efficiency) in each case. But this opens up a host of inquiries. Should the court naively determine the necessary reward based on the actual costs of the patentholder? Should the factual inquiry about costs instead consider that some other inventor could have achieved the patent more cheaply and that too much reward only encourages waste? Should the inquiry consider that research is risky and that discoverers would only have invested if they expected a super-reward for success? Given that the research endeavor was eventually successful, what evidence could be adduced to show that it might not have been and with what probability?

15. The ratio test has been revived by authors studying patent breadth; see chapter 4 of Scotchmer (2004) for a summary.

16. Kaplow admits that in practice it is probably impossible to estimate Congress's subjective cost/benefit judgment by analyzing the patent statutes. He therefore proposes a less ambitious use of his ratio called cost-effectiveness. This procedure asks judges to reshuffle the law by making currently permitted licenses with low ratios illegal in exchange for legalizing currently prohibited practices with high ratios. Kaplow concedes, however, that even this more modest project may not be possible given current uncertainty about the "economic effects of various restrictive practices."

The ways that such an inquiry can go astray are almost endless, as noted by other commentators. First, the factual inquiry is so complex as to be unavoidably speculative and may defer to ideological prejudice. Baxter (1966) argues that the weighing of proper rewards is "peculiarly appropriate" to the political branches of government.[17] Of course, one can argue that judges' opinions do not matter provided that Congress can easily correct them. In practice, most judicial attempts to weigh ex ante and ex post efficiency will never be reviewed, much less corrected.

Second, any such inquiry requires specialized knowledge and is likely to be lengthy and complex. Landes and Posner (2003) argue that the ex ante/ex post tradeoff "may well be beyond the capacity of the courts." Kaplow (1984) is more optimistic, observing that the required analysis "is probably more developed at both the theoretical and empirical levels than is the analysis of a vast array of other issues that the courts regularly confront."

Third, the inquiry will almost always depend on parties and evidence not before the court. Except when the government is a party or citizens file amicus briefs, the interests of third parties will almost always be underrepresented. However, there is reason to suspect that many patent agreements derive their value "precisely because [they] are injurious to third persons" (Baxter, 1966). The temptation to impose costs on third parties—who are seldom in a position to know, let alone complain—may be overwhelming.

Fourth, permitting judges to set the balance each time they decide a case will inevitably make patent rewards less certain (Adelman and Juenger, 1975; Bork, 1978). Inventors will demand a larger reward—with greater attendant deadweight loss—for any given level of inventive effort (Gifford, 2002).

Fifth, courts almost always examine controversies ex post, whereas legislatures and executive agencies tend to make policy ex ante. As the particular innovation before the court cannot be uninvented, there may be a built-in bias toward addressing antitrust issues at the expense of innovation. More broadly, judges may conclude that their judgment in a single

17. Balancing innovation against ex post deadweight loss also requires normative judgments about intergenerational transfers. Judges have no objective standards for deciding "whether, in any given case, it would be desirable to sacrifice more or less consumer satisfaction of other wants by devoting more or fewer resources to the promotion of innovation" (Bork, 1965).

case cannot possibly affect innovation in the broader society. Nevertheless, the aggregate effect of court decisions will likely be substantial.

7. Conclusion

Subsequent case law has made the *General Electric* price-fixing exception quite narrow. Critics have therefore argued that the price-fixing exception is a discredited "vestige." We disagree. Based on the analysis above, a narrow price-fixing exception is consistent with the three principles of derived reward, profit neutrality, and minimalism where marginal cost of production is increasing.

Our analysis also sheds light on *Line Material*. We interpret the *Line Material* agenda as an attempt to preserve competition between infringing patentholders when the infringement is a strategic choice, i.e., when a noninfringing alternative would have been possible. The strategic choice itself should not be rewarded. Competition can be preserved by disallowing covenants that take the unimproved product off the market. Without such a covenant, *General Electric* style price fixing is not a very attractive tool, so the Court is justified in suspecting an illegitimate purpose.

Under our derived-reward principle, it is justifiable to suppress the prior product and to avoid competition between the patentholders if the prior product is a necessary foundation for the improved product. The improvement implements an option created by the prior product, and its social value can be counted as part of the social value created by the prior patentholder. In that case, we assume that the patents are inevitably blocking. Here, we would limit *Line Material* by allowing the parties to suppress the underlying invention and to earn a full monopoly reward on the improved product. Price fixing can then be justified in the same way as in *General Electric*, namely, to support productive efficiency. Nonlinear royalties and quantity constraints would be acceptable for the same purpose.

Our analysis based on the three principles is more favorable to per se rules than is currently the fashion. The alternative, rule of reason, must be applied with some well-articulated objective in mind. One problem is that there is no consensus on the right objective, and another is that the main proposals are hard to implement on the basis of facts likely to be before a court. Consequently, rule of reason gives scope for unpredictability in outcomes, which creates uncertainty for patentholders and reduces

Congress's control over patent incentives. Uncertainty can chill patentholders' willingness to write creative license terms, even when justified, and consequently can chill their ability to exploit patented knowledge. On the positive side, rule of reason lets judges tailor rewards to individual circumstances. However, the required inquiry is so inherently speculative that flexibility may not lead to any net improvement.

We do not suggest that our three principles will give guidance in every licensing situation. But where they apply, such as in the core patent/antitrust cases of the twentieth century that we have discussed, they bound the inquiry by economic considerations of efficiency. Courts may occasionally have stumbled over the economics, but their approach to licensing, which we interpret to be based on our three principles, seems sound.

Appendix

The Formal Arguments

In this appendix, we give formal arguments for the intuitive arguments in Sections 3 and 4.

New-Product Patents.

We assume the demand and cost structure described in Section 3. The profit-neutrality question is whether the patentholder can achieve the profit-maximizing supplies, $q_1 = q_2 = (q^*/2)$, where q^* is the monopoly price defined by equation (2). Ignoring the fixed fees, which are assumed sunk once the license is signed, the profit functions of the licensee and licensor are

$$\pi_1(q_1; q_2, \rho) = (1 - q_1 - q_2 - \rho)q_1 - \Gamma(q_1)$$
$$\pi_2(q_2; q_1, \rho) = (1 - q_1 - q_2)q_2 + \rho q_1 - \Gamma(q_2).$$

Conditional on a license $(\rho,\ F)$ with a constant royalty ρ, an *equilibrium* is a pair of quantities $(q_1,\ q_2)$, such that $\pi_1(q_1; q_2, \rho) \geq \pi_1(\hat{q}_1; q_2, \rho)$ for all $\hat{q}_1 \geq 0$ and $\pi_2(q_2; q_1, \rho) \geq \pi_2(\hat{q}_2; q_1, \rho)$ for all $\hat{q}_2 \geq 0$.

Proposition 1. If the marginal cost of producing a new, patented product is increasing in each plant, there is no constant-royalty license $(\rho,\ F)$, such that an equilibrium achieves the profit-maximizing quantities $q_1 = q_2 = (q^*/2)$.

Proof. The licensor's optimal supply $\tilde{q}_2$, as a function of the licensee's output q_1, maximizes π_2 and is given by

$$\tilde{q}_2(q_1) = \frac{1}{2}[1 - q_1 - \gamma(q_2)].$$

The licensee's optimal supply $\tilde{q}_1$, as function of the licensor's output q_2, maximizes π_1 and satisfies

$$\tilde{q}_1(q_2) = \frac{1}{2}[1 - q_2 - \gamma(q_1) - \rho].$$

If $\rho = 0$, the equilibrium $(q_2,\ q_1) = [\tilde{q}_2(q_1), \tilde{q}_1(q_2)]$ is the duopoly outcome, not the monopoly outcome. If $\rho > 0$, the equilibrium does not satisfy $q_1 = q_2$, as

$$q_2 + \gamma(q_2) = q_1 + \rho + \gamma(q_1).$$

This proves the result.

The price term in the *General Electric* license was not "price fixing" but rather "price matching." That is, the licensee was restricted to charge the same price as the licensor. Our interpretation is that the licensor chooses the price for both firms and also the royalty rate, and then the firms choose their supplies. We now show that a license that fixes the licensee's price, but not the licensor's price, will not achieve profit neutrality.

If the licensee's price is fixed, and the licensor's price can change to clear the market, the firms may end up selling at different prices. This makes the analysis a bit complicated, as all the consumers prefer to buy the lower priced units, which must be rationed. The market outcome with a price-fixing clause will depend on the rationing rule. However, we can show under reasonable assumptions about rationing that price fixing does not achieve efficiency and does not achieve the benchmark level of profits for the patentholder.

The rationing rule is given by Assumption 1, which is phrased in terms of a fixed price p_F and a variable price p_V. The quantities offered by the firms with these two prices are called $(q_F,\ q_V)$.

Assumption 1. Suppose two firms, F and V, offer perfect substitutes in quantities $(q_F,\ q_V)$. Let p_F be a fixed price charged by firm F, and let p_V be a variable price charged by firm V. For $a > 0$, let the market demand function be defined by $a - p$.

(a) If $(a - p_F) \leq (q_F + q_V)$ (there is excess supply at price p_F), then the price p_V is defined by equation (14), and $p_V < p_F$. The sales of firm V are q_V, and the sales of firm F are $[q_F/(q_F + q_V)]\ (a - p_F)$.

$$\begin{aligned} p_V &= \max\{0, \frac{q_V}{q_F + q_V}[a - (q_F + q_V)] + \frac{q_F}{q_F + q_V} p_F\} \\ &= \max\{0, (a - q_V) - \frac{q_F}{q_F + q_V}(a - p_F)\}. \end{aligned} \tag{14}$$

(b) If $(a - p_F) > (q_F + q_V)$ (there is excess demand at price p_F), then the price p_V is defined by (15), and $p_V > p_F$. Both firms sell their supplies, q_V and q_F.

$$p_V = \max\{0, a - (q_V + q_F)\}. \tag{15}$$

Owing to excess supply at the fixed price, Assumption 1(a) says that the variable price must be lower than the fixed price. But as all customers will prefer the lower price, there must be a rationing rule that says who will purchase at that price. The customers with willingness to pay higher than the lower price p_V are randomly assigned to the two firms, with probabilities that reflect the relative supplies. Thus, each customer has probability $[q_F/(q_F + q_V)]$ of first visiting the high-priced firm and probability $[q_V/(q_F + q_V)]$ of first visiting the low-priced firm. All customers who visit the low-priced firm purchase. (There are $[q_V/(q_F + q_V)](a - p_V)$ of them.) All customers who visit the high-priced firm and also have willingness to pay higher than p_F purchase from the high-priced firm. The customers who visit the high-priced firm and have willingness to pay between p_V and p_F (there are $[q_F/(q_F + q_V)](p_F - p_V)$ of them) are bounced to the other firm, with lower price. The assumption is that the low price p_V adjusts so that the quantity supplied is sold, whereas the high-priced firm may end up with excess supply.

Owing to excess demand at the fixed price, Assumption 1(b) says that the variable price must be higher than the fixed price. If the customers who purchase from the lower-priced firm are randomly selected, there are only a fraction $[q_V/(q_F + q_V)]$ of customers remaining for the other firm at each willingness to pay above p_V. If p_V satisfies (15), the higher-priced firm sells its supply.

There is an asymmetry in parts (a) and (b) as to whether both firms sell their supplies. The higher priced firm will not sell all its supply if the price is fixed, because some of the customers with high willingness to pay who would otherwise purchase from that firm manage to purchase from the firm with lower price.

The price p_V defined by equations (14) and (15) can be understood as a function $\tilde{p}(q_V,\ q_F,\ p_F)$ with derivatives

$$\frac{\partial}{\partial q_V}\tilde{p}(q_V, q_F, p_F) = \frac{a - p_F}{q_V + q_F}\ \frac{q_F}{q_V + q_F} - 1, \quad \text{if } a - p_F \le q_F + q_V$$

$$\frac{\partial}{\partial q_V}\tilde{p}(q_V, q_F, p_F) = -1, \quad \text{if } a - p_F > q_F + q_V.$$

The derivative is negative and between –1 and 0 at every $(q_V,\ q_F,\ p_F)$.

Our first objective, using this rationing rule, is to show that, if only the licensee's price is fixed, the license cannot support optimal production. To do

that we must formulate the game played by the licensor and licensee, using the rationing rule. Again, let the licensee and licensor be firms 1 and 2, supplying q_1 and q_2. Their profit functions are $\bar{\pi}_1$ and $\bar{\pi}_2$, where $a = 1$.

$$\bar{\pi}_1(q_1; q_2, p_F, \rho) = \left\{ \begin{array}{ll} q_1(p_F - \rho) - \Gamma(q_1), & \text{if } q_1 \leq a - p_F - q_2 \\ \frac{q_1}{q_2+q_1}(p_F - \rho)(a - p_F) - \Gamma(q_1), & \text{if } q_1 > a - p_F - q_2 \end{array} \right\}$$

$$\bar{\pi}_2(q_2; q_2, p_F, \rho)$$

$$= \left\{ \begin{array}{ll} q_2\tilde{p}(q_2, q_1, p_F) + q_1\rho - \Gamma(q_2), & \text{if } q_2 \leq a - p_F - q_2 \\ q_2\tilde{p}(q_2, q_1, p_F) + \frac{q_1}{q_2+q_1}(a - p_F)\rho - \Gamma(q_2), & \text{if } q_2 > a - p_F - q_1 \end{array} \right\}$$

We will also use the derivatives:

$$\frac{\partial}{\partial q_1}\bar{\pi}_1(q_1; q_2, p_F, \rho)$$

$$= \left\{ \begin{array}{ll} \frac{q_2}{q_2+q_1}(p_F - \rho)\frac{a-p_F}{q_2+q_1} - \gamma(q_1), & \text{if } q_1 > a - p_F - q_2 \\ (p_F - \rho) - \gamma(q_1), & \text{if } q_1 < a - p_F - q_2 \end{array} \right\}$$

$$\frac{\partial}{\partial q_2}\bar{\pi}_2(q_2; q_2, p_F, \rho)$$

$$= \left\{ \begin{array}{ll} \left(\frac{q_1}{q_2+q_1}\frac{a-p_F}{q_2+q_1} - 1\right)q_2 + \tilde{p}(q_2, q_1, p_F) & \\ \qquad - \frac{q_1}{q_2+q_1}\frac{a-p_F}{q_2+q_1}\rho - \gamma(q_2), & \text{if } q_2 \leq a - p_F - q_1 \\ \tilde{p}(q_2, q_1, p_F) - q_2 - \gamma(q_2), & \text{if } q_2 \leq a - p_F - q_1 \end{array} \right\}.$$

Let (p_F, ρ) be a license that fixes the price of the licensee (but not the licensor). Then (q_1, q_2) is an equilibrium if it satisfies $\bar{\pi}_1(q_1; q_2, p_F, \rho) \geq \bar{\pi}_1(\hat{q}_1; q_2, p_F, \rho)$ for all $\hat{q}_1 \geq 0$ and $\bar{\pi}_2(q_2, q_1, p_F, \rho) \geq \bar{\pi}_2(\hat{q}_2, q_1, p_F, \rho)$ for all $\hat{q}_2 \geq 0$.

Proposition 2. Suppose that the marginal cost of producing a new, patented product is increasing in each plant and that the patentholder will compete with a single licensee. Suppose that Assumption 1 holds. There is no license (p_F, ρ) that fixes only the price of the licensee, such that $(q^*/2, q^*/2)$ is an equilibrium of the resulting game, and $p_F = a - q^*$.

Proof. Suppose there is such a license. In order that the licensee is at a profit maximum, the royalty must satisfy

$$\frac{1}{2}(p_F - \rho) \leq \gamma\left(\frac{q^*}{2}\right) \leq (p_F - \rho). \tag{16}$$

However, the licensor then has an incentive to opportunistically increase supply beyond $q^*/2$ and increase his/her own profit at the licensee's expense. If the licensor increases supply, there will be excess supply at the price p_F, and the licensor's price will fall. The righthand derivative of $\bar{\pi}_2$ with respect to q_2 at $q_2 = (q^*/2)$ is $-(1/2)q_2 + p_F - (1/2)\rho - \gamma(q_2)$. Using $-\rho \geq -[p_F - \gamma(q^*/2)]$ from equation (16) and $q_2 = (q^*/2)$

$$-\frac{1}{2}q_2 + p_F - \frac{1}{2}\rho - \gamma(q_2) \geq \frac{1}{2}[p_F - \gamma(q_2)] - \frac{1}{2}q_2$$

$$= \frac{1}{2}\left[a - q^* - \gamma\left(\frac{q^*}{2}\right)\right] - \frac{1}{2}\frac{q^*}{2} = \frac{1}{2}(q^* - \frac{q^*}{2}) > 0.$$

As the right derivative is positive, the licensor can profit by increasing output.

Quality Improvements.

We now adopt the structure described in section 4, where firm 1 has a patented product and firm 2 has a patented improvement on it, which may be infringing or noninfringing. We will use $q^*(\Delta)$ to designate the (total) monopoly supply of the improved good. The monopoly supply is increasing in Δ and satisfies

$$0 = 1 + \Delta - 2q^*(\Delta) - \gamma\left(\frac{q^*(\Delta)}{2}\right).$$

Assumption 2 is the natural rationing rule for the license that fixes the price of both firms and is consistent with our intuitive argument in Section 3 for why price fixing can sustain the monopoly price on a new product.

Assumption 2. Suppose that the price of firms 1 and 2 is fixed at p_F. Then if $q_1 + q_2 > 1 + \Delta - p_F$, firms 1 and 2 sell $\left[\frac{q_1}{(q_1+q_2)}\right]$ and $\left[\frac{q_2}{(q_1+q_2)}\right]$ units, respectively. Otherwise, they sell q_1 and q_2.

The profit functions of firms 1 and 2 are $\hat{\pi}_1$ and $\hat{\pi}_2$ if they supply the improved good in amounts (q_1, q_2) at the fixed price p_F, and firm 1 also supplies q_u at the variable price given by

$$\tilde{p}(q_u, q_1 + q_2, p_F) = 1 - q_u - \frac{q_1 + q_2}{q_1 + q_u + q_2}(1 + \Delta - p_F).$$

Again we ignore the fixed fees in these profit functions, assuming that they cannot be avoided once the license is signed. The derivatives of the following profit functions are evaluated at $(q_1, q_u, q_2, p_F, \rho)$ where $q_u = 0$.

$$\hat{\pi}_1(q_1, q_u, q_2, p_F, \rho)$$
$$= \left\{ \begin{array}{ll} q_1(p_F - \rho) + q_u(p_F - \Delta) - \Gamma(q_1 + q_u), & \text{if } q_1 + q_u \le 1 + \Delta - p_F - q_2 \\ \frac{q_1}{q_1+q_u+q_2}(1 + \Delta - p_F)(p_F - \rho) & \\ \quad + q_u \tilde{p}(q_u, q_1 + q_2, p_F) - \Gamma(q_1 + q_u), & \text{if } q_1 + q_u > 1 + \Delta - p_F - q_2 \end{array} \right\}$$

$$\hat{\pi}_2(q_2, q_1, q_u, p_F, \rho)$$
$$= \left\{ \begin{array}{ll} q_2 p_F + q_1 \rho - \Gamma(q_2), & \text{if } q_2 \le 1 + \Delta - p_F - q_1 - q_u \\ \left(p_F \frac{q_2}{q_1+q_u+q_2} + \rho \frac{q_1}{q_1+q_u+q_2} \right) & \\ \quad \mathrm{X}(1 + \Delta - p_F) - \Gamma(q_2), & \text{if } q_2 > 1 + \Delta - p_F - q_1 - q_u \end{array} \right\}$$

$$\frac{\partial}{\partial q_1} \hat{\pi}_1(q_1, q_u, q_2, p_F, \rho)$$
$$= \left\{ \begin{array}{ll} (p_F - \rho) - \gamma(q_1 + q_u), & \text{if } q_1 + q_u \le 1 + \Delta - p_F - q_2 \\ \frac{q_2+q_u}{(q_1+q_u+q_2)^2}(1 + \Delta - p_F) & \\ \quad \mathrm{X}(p_F - \rho) - \gamma(q_1 + q_u), & \text{if } q_1 + q_u > 1 + \Delta - p_F - q_2 \end{array} \right\}$$

$$\frac{\partial}{\partial q_u} \hat{\pi}_1(q_1, q_u, q_2, p_F, \rho)$$
$$= \left\{ \begin{array}{ll} (p_F - \Delta) - \gamma(q_1 + q_u), & \text{if } q_1 + q_u \le 1 + \Delta - p_F - q_2 \\ -\frac{q_1}{(q_1+q_u+q_2)^2}(1 + \Delta - p_F)(p_F - \rho) & \\ \quad + \tilde{p}(q_u, q_1 + q_2, p_F) & \\ \quad - q_u \left[1 - \frac{q_1+q_2}{(q_1+q_u+q_2)^2}(1 + \Delta - p_F) \right] & \\ \quad - \gamma(q_1 + q_u), & \text{if } q_1 + q_u > 1 + \Delta - p_F - q_2 \end{array} \right\}$$

$$\frac{\partial}{\partial q_2} \hat{\pi}_2(q_2, q_1, q_u, p_F, \rho)$$
$$= \left\{ \begin{array}{ll} p_F - \gamma(q_2), & \text{if } q_2 \le 1 + \Delta - p_F - q_1 - q_u \\ \frac{q_1}{(q_1+q_u+q_2)^2} & \\ \quad \mathrm{X}(p_F - \rho)(1 + \Delta - p_F) - \gamma(q_2), & \text{if } q_2 > 1 + \Delta - p_F - q_1 - q_u \end{array} \right\}.$$

Say that (q_1, q_u, q_2) is an *equilibrium with a fixed-price license* (p_F, ρ) if $\hat{\pi}_2(q_2, q_1, q_u, p_F, \rho) \ge \hat{\pi}_2(\hat{q}_2, q_1, q_u, p_F, \rho)$ for all $\hat{q}_2 \ge 0$ and $\hat{\pi}_1(q_1, q_u, q_2, p_F, \rho) \ge \hat{\pi}_1(\hat{q}_1, \hat{q}_u, q_2, p_F, \rho)$ for all $\hat{q}_1, \hat{q}_u \ge 0$. Say that the fixed-price license *supports an efficient equilibrium* (q_1, q_u, q_2) if the equilibrium satisfies $q_1 = q_2$, $q_u = 0$, and $p_F = 1 + \Delta - (q_1 + q_2)$.

According to the following proposition, price fixing is not a very effective tool for supporting the monopoly price. For small Δ, an efficient equilibrium will have greater supply than would arise with a royalty-free license, namely the duopoly supply $q^D(\Delta)$.

Proposition 3. [Fixing the Price of Both Firms.] Suppose that Assumptions 1 and 2 hold and that the improved product is noninfringing.

(a) If a fixed-price license (p_F, ρ) supports an equilibrium in which the licensee does not supply the unimproved product $(q_u = 0)$, it holds that $\rho < \Delta$.

(b) Suppose that marginal cost satisfies $\gamma(q) = bq,\ b > 0$. If a fixed-price license supports an efficient equilibrium $(q_I, q_u, q_2) = (q, 0, q)$ and (17) holds, then $q > q^D(\Delta)$

$$\Delta < \frac{1-b}{2(1+b)}. \tag{17}$$

Proof. (a) Suppose that (p_F, ρ) is a fixed-price license and $(q_1, 0, q_2)$ is an equilibrium. As $\hat{\pi}_1(0, q_1, q_2, p_F, \rho) > \hat{\pi}_1(q_1, 0, q_2, p_F, \rho)$ when $\rho > \Delta$, firm 1 can make strictly greater profit by selling q_1 units of the unimproved product instead of the improved product, which contradicts that $(q_1, 0, q_2)$ is an equilibrium. We conclude that $\rho \leq \Delta$.

(b) The licensee's optimization condition at $(q_1, q_u, q_2, p_F, \rho)$ where $q_u = 0$ includes the following conditions on the left and right derivatives of the profit function.

$$\frac{\partial}{\partial q_1}\hat{\pi}_1^L = p_F - \rho - bq_1 \geq 0, \qquad \text{if } q_1 < 1 + \Delta - p_F - q_2$$
$$\frac{\partial}{\partial q_1}\hat{\pi}_1^R = \frac{1}{2}(p_F - \rho) - bq_1 \leq 0, \quad \text{if } q_1 > 1 + \Delta - p_F - q_2.$$

Together with $p_F = 1 + \Delta - 2q$, this implies that if $(q, 0, q)$ is an equilibrium,

$$\frac{1+\Delta-\rho}{2+2b} \leq q \leq \frac{1+\Delta-\rho}{2+b}. \tag{18}$$

The inequality (17) is equivalent to

$$\frac{1+\Delta}{3+b} < \frac{1}{2+2b}$$

and as $\Delta - \rho > 0$,

$$q^D(\Delta) = \frac{1+\Delta}{3+b} < \frac{1}{2+2b} \leq \frac{1+\Delta-\rho}{2+2b} \leq q. \tag{19}$$

■

Given the limitations on fixed-price licensing, we now consider nonlinear royalties and quantity restrictions. These are equivalent. If the licensor wants

to implement the quantities (q_1, q_2), he can charge zero royalty at q_1 but impose a large surcharge if the licensee deviates to $q \neq q_1$ and can commit to a large rebate if he himself deviates to $q \neq q_2$. (There may be a loss in what can be implemented if a negative royalty cannot be imposed when the licensor deviates.)

Potential competition from the unimproved product will again constrain the license.

Recognizing that (q_1, q_2) are fixed by the licence, the quantities $(q_1, 0, q_2)$ are an *equilibrium with quantity constraints* if

$$\begin{aligned} &q_u(1 - q_u - q_1 - q_2) + q_1(1 + \Delta - q_u - q_1 - q_2) - \Gamma(q_u + q_1) \\ &\quad \leq q_1(1 + \Delta - q_1 - q_2) - \Gamma(q_1), \quad \text{for every } q_u \in [0, \infty). \end{aligned} \tag{20}$$

Proposition 4. [Quantity Constraints.] Suppose that the improved and unimproved products are both patented but noninfringing. Then if an equilibrium $(q_1, q_u, q_2) = (q, 0, q)$ is supported by quantity constraints, it holds that $q \geq q^D(0)$.

Proof. As the derivative of the lefthand side of (20) is decreasing with q_u, a necessary and sufficient condition for the equilibrium condition (20) to hold is

$$\begin{aligned} &\frac{\partial}{\partial q_u}\left[q_u(1 - q_u - q_1 - q_2) + q_1(1 + \Delta - q_u - q_1 - q_2) - \Gamma(q_u + q_1)\right] \\ &\quad = 1 - 2q_u - 2q_1 - q_2 - \gamma(q_u + q_1) = 1 - 2q_u - 3q - \gamma(q + q_u) \\ &\quad \leq 1 - 3q - \gamma(q) \leq 0 \end{aligned}$$

This implies that $q \geq q^D(0)$. ∎

Thus, the quantities supplied will be at least as high as would arise in a duopoly in which both firms supply the unimproved product. This might be good news, except for the fact, shown in the next proposition, that inefficient production is more profitable. The licensor can reduce the threat of entry while preserving a high price if the license provides for asymmetric (inefficient) supply. Proposition 5 again focuses on joint profits, assuming that profit can be divided by fixed fees.

Proposition 5. [Inefficient Quantity Constraints.] Suppose that the improved and unimproved products are both patented but noninfringing. Suppose that $(q, 0, q)$ is an equilibrium with quantity constraints. Then there is another equilibrium $(q + \mathrm{d}q_1, 0, q + \mathrm{d}q_2)$, where $\mathrm{d}q_1 > 0$, that increases joint profit.

Proof. As the derivative of the lefthand side of (20) is decreasing with q_u, a sufficient condition for the equilibrium condition (20) to hold for an equilibrium $(q_1, 0, q_2)$ is

$$\frac{\partial}{\partial q_u} q_u\,(1 - q_u - q_1 - q_2) + q_1(1 + \Delta - q_u - q_1 - q_2) - \Gamma(q_u + q_1)$$
$$= 1 - 2q_u - 2q_1 - q_2 - \gamma(q_u + q_1) \leq 1 - 2q_1 - q_2 - \gamma(q_1) \leq 0.$$

The incentive constraint will also hold for $(q_1 + \mathrm{d}q_1, 0, q_2 + \mathrm{d}q_2)$ if they satisfy

$$\mathrm{d}q_2 = -[2 + \gamma'(q_1)]\mathrm{d}q_1 \tag{21}$$
$$\mathrm{d}q_1 + \mathrm{d}q_2 = -[1 + \gamma'(q_1)]\mathrm{d}q_1.$$

The joint profit of the two firms and the derivative of profit as the quantities supplied change are given by

$$\Pi(q_1, q_2, \Delta) = (q_1 + q_2)[1 + \Delta - (q_1 + q_2)] - \Gamma(q_1) - \Gamma(q_2)$$
$$\mathrm{d}\Pi = [1 + \Delta - 2(q_1 + q_2)](\mathrm{d}q_1 + \mathrm{d}q_2) - \gamma(q_1)\mathrm{d}q_1 - \gamma(q_2)\mathrm{d}q_2.$$

Starting from $(q_1, 0, q_2) = (q, 0, q)$,

$$\mathrm{d}\Pi = [1 + \Delta - 4q - \gamma(q)](\mathrm{d}q_1 + \mathrm{d}q_2)$$
$$= -[1 + \Delta - 4q - \gamma(q)][1 + \gamma'(q_1)]\mathrm{d}q_1.$$

As $q > (q^*/2)$, the term in brackets is negative. Thus, to create an increase in profit, it must hold that $\mathrm{d}q_1 > 0$, and $\mathrm{d}q_2$ satisfies (21). ■

For completeness, we also consider licenses that fix the licensee's price but not the licensor's price. Say that (p_F, ρ) is a *one-sided fixed-price license* if it fixes only the price of the licensee. The profit functions and their derivatives are[18]

18. A more proper definition of $\tilde{\pi}_1$ would substitute 0 if $\tilde{p}(\cdot) - \Delta < 0$. However, this imprecision will not matter for the proposition we prove, as the optimal choice will be $q_u = 0$ in that case.

$$\tilde{\pi}_1(q_1, q_u, q_2, p_F, \rho)$$
$$= \left\{ \begin{array}{ll} q_1(p_F - \rho) + q_u(1 - q_2 - q_1 - q_u) & \\ -\Gamma(q_1 + q_u), & \text{if } q_1 + q_u \leq a - p_F - q_2 \\ \frac{q_1}{q_2+q_1+q_u}(p_F - \rho)(a - p_F) & \\ \quad + q_u[\tilde{p}(q_u + q_2, q_1, p_F) - \Delta] - \Gamma(q_1 + q_u), & \text{if } q_1 + q_u > a - p_F - q_2 \end{array} \right\}$$
$$\tilde{\pi}_2(q_1, q_u, q_2, p_F, \rho)$$
$$= \left\{ \begin{array}{ll} q_2(1 + \Delta - q_2 - q_1 - q_u) & \\ +q_1\rho - \Gamma(q_1 + q_u), & \text{if } q_2 \leq a - p_F - (q_1 + q_u) \\ \frac{q_1}{q_2+q_1+q_u}(a - p_F)\rho & \\ \quad + q_2\tilde{p}(q_u + q_2, q_1, p_F) - \Gamma(q_2), & \text{if } q_2 > a - p_F - (q_1 + q_u) \end{array} \right\}$$
$$\frac{\partial}{\partial q_u}\tilde{\pi}_1(q_1, q_u, q_2, p_F, \rho)$$
$$= \left\{ \begin{array}{ll} (1 - q_2 - q_1 - 2q_u) - \gamma(q_1 + q_\mu), & \text{if } q_1 + q_u \leq a - p_F - q_2 \\ -\left[1 - \frac{q_1(1+\Delta-p_F)}{(q_2+q_1+q_u)^2}\right] q_u + \tilde{p}(q_u + q_2, q_1, p_F) & \\ \quad -\Delta - \frac{q_1}{q_2+q_1+q_u}(p_F - \rho)\frac{a-p_F}{q_2+q_1+q_u} & \\ \quad -\gamma(q_1 + q_u), & \text{if } q_1 + q_u > a - p_F - q_2 \end{array} \right\}$$
$$\frac{\partial}{\partial q_1}\tilde{\pi}_1(q_1, q_u, q_2, p_F, \rho)$$
$$= \left\{ \begin{array}{ll} (p_F - \rho) - q_u - \gamma(q_1 + q_u), & \text{if } q_2 \leq a - p_F - q_1 - q_u \\ \frac{q_2+q_u}{q_2+q_1+q_u}\ \frac{a-p_F}{q_2+q_1+q_u}(p_F - \rho) & \\ \quad -q_u\frac{q_2+q_u}{(q_2+q_1+q_u)^2}(1 + \Delta - p_F) - \gamma(q_1 + q_u), & \text{if } q_2 > a - p_F - q_1 - q_u \end{array} \right\}$$
$$\frac{\partial}{\partial q_2}\tilde{\pi}_2(q_1, q_u, q_2, p_F, \rho)$$
$$= \left\{ \begin{array}{ll} (1 + \Delta - 2q_2 - q_1 - q_u) - \gamma(q_2), & \text{if } q_2 \leq a - p_F - q_1 - q_u \\ -\left[1 - \frac{q_1(1+\Delta-p_F)}{(q_2+q_1+q_u)^2}\right] q_2 + \tilde{p}(q_u + q_2, q_1, p_F) & \\ \quad -\frac{q_1}{q_2+q_1+q_u}\ \frac{a-p_F}{q_2+q_1+q_u}\rho - \gamma(q_2), & \text{if } q_2 > a - p_F - q_1 - q_u \end{array} \right\}.$$

Say that (q_1, q_u, q_2) is an *equilibrium with a one-sided fixed-price license* (p_F, ρ) if $\tilde{\pi}_2(q_1, q_u, q_2, p_F, \rho) \geq \tilde{\pi}_2(q_1, q_u, \hat{q}_2, p_F, \rho)$ for all $\hat{q}_2 \geq 0$ and $\tilde{\pi}_1(q_1, q_u, q_2, p_F, \rho) \geq \tilde{\pi}_1(\hat{q}_1, \hat{q}_u, q_2, p_F, \rho)$ for all $\hat{q}_1, \hat{q}_u \geq 0$. Say that a one-sided fixed-price license (p_F, ρ) *supports an efficient equilibrium* if an equilibrium (q_1, q_u, q_2) satisfies $q_1 = q_2,\ q_u = 0$, and $p_F = 1 + \Delta - q_1 + q_2$.

The following proposition implies that efficient production can only be supported if the improvement is relatively large, and then only at a price

lower than the monopoly price. (When $\Delta < 1 + b$, the monopoly supply $q^*(\Delta)$ is less than the duopoly supply $2q^D(\Delta/2)$.) The licensor, whose price is free to vary, is always tempted to increase supply. He will be penalized by having to sell at a lower price, but the fall in price is tempered because the licensee cannot similarly lower his price. The main thing that restrains the licensor from increasing supply is that he loses royalties when he crowds out sales by the licensee. But if Δ is small, the royalty must also be small to keep the licensee from reverting to the unimproved product. The crowding out is then not very costly.

Proposition 6. [Fixing Only the Price of the Licensee.] Suppose that Assumption 1 holds and that the improved product is noninfringing.

(a) If $(\mathrm{p_F}, \rho)$ is a one-sided fixed-price license and $(q_1, q_u, q_2) = (q, 0, q)$ is an efficient equilibrium, then $\Delta \geq \rho$ and $q^D(\Delta/2) \leq q \leq \Delta$.

(b) Suppose that γ can be written $\gamma(q) = bq$. If a one-sided fixed-price license supports an efficient equilibrium, it holds that

$$\frac{2}{5+2b} \leq \Delta.$$

Proof. (a) First, $\Delta \geq \rho$ because otherwise the licensee can increase profit by substituting the unimproved product for the improved product. To see the inequality, we first write the derivatives of the profit functions, evaluated at an efficient equilibrium $(q_1, q_u, q_2) = (q, 0, q)$.

$$\frac{\partial}{\partial q_1}\tilde{\pi}_1(q_1, q_u, q_2, p_F, \rho) = \left\{ \begin{array}{ll} (1 + \Delta - 2q - \rho) - \gamma(q), & \text{if } 2q < 1+\Delta-p_F \\ \frac{1}{2}(1 + \Delta - 2q - \rho) - \gamma(q), & \text{if } 2q > 1+\Delta-p_F \end{array} \right\}$$

$$\frac{\partial}{\partial q_2}\tilde{\pi}_2(q_1, q_u, q_2, p_F, \rho) = \left\{ \begin{array}{ll} 1 + \Delta - 3q - \gamma(q), & \text{if } 2q < 1 + \Delta - p_F \\ 1 + \Delta - 3q & \\ \quad + \frac{1}{2}(q - \rho) - \gamma(q), & \text{if } 2q > 1 + \Delta - p_F \end{array} \right\}.$$

In order that $\tilde{\pi}_2$ is locally concave at $(q_1, 0, q_2) = (q, 0, q)$, it holds that $q \leq \rho$, hence $q \leq \Delta$. Suppose that $q < q^D(\Delta/2)$. Then $1 + (\Delta/2) - 3q - \gamma(q) > 0$. But

$$\begin{aligned} 1 + \Delta - 3q + \frac{1}{2}(q - \rho) - \gamma(q) &> 1 + \Delta - 3q - \frac{1}{2}\rho - \gamma(q) \\ &> 1 + \Delta - 3q - \frac{1}{2}\Delta - \gamma(q) > 1 + \frac{\Delta}{2} - 3q - \gamma(q) > 0, \end{aligned}$$

which contradicts that the right derivative of $\tilde{\pi}_2$ must be nonpositive at an equilibrium. Thus firm 2 could increase profit by increasing output.

(b) The inequality follows in the case $\gamma(q) = bq$ from $\Delta \geq q^D(\Delta/2)$. ■

However, if the license can impose a fixed price on the licensee but not the licensor, the firms might prefer a license that is productively inefficient. This is for a different reason than with quantity constraints. Example 1 shows that a license that leads to different prices can facilitate price discrimination through the rationing rule. The license in Example 1 fixes the price of the licensee to be very high—even higher than the monopoly price. The licensor then offers so much supply that he must sell his units at a lower price—lower than the monopoly price. The licensee ends up with excess supply in his attempt to crowd out sales from the licensor, but the units he sells are so profitable at the high fixed price that total profit is higher than a single-price monopolist would attain.

There is nothing in Example 1 that is specific to improved products; it would apply equally well to a new product patent.[19] In the text, we focus on licenses that fix the price of both parties because that more accurately describes *General Electric*, and because this possibility for price discrimination seems anomalous, especially as it requires excess supply.

Example 1. [**Price Discrimination through One-Sided Price Fixing**.] Let $\Delta = 0.1$ and $\gamma(q) = 0.1q$. The monopoly price is $p^* = 0.563$, and monopoly profit with efficient production at a common price is 0.295.

We assert that the license $(p_F, \rho) = (0.58, 0)$ supports an equilibrium $(q_1, 0, q_2) = (0.82, 0, 0.415)$, and the quantities actually sold are (0.3453, 0.415). If all the units were sold, there would be excess demand at price zero. But as the high-priced firm (licensee) sells less than half his units, the prices are $p_F = 0.58$ and $p_V = 0.3397$. Everyone prefers to buy at the lower price (the licensor's price), and everyone with willingness to pay higher than the lower price buys a unit, but some buyers are rationed to the higher-priced firm. The total profit is 0.299, which is larger than the monopoly profit with efficient production at a common price.

To see formally that this is an equilibrium, one must check that each firm's strategy optimizes its payoff function and that the licensee cannot increase profit by reverting to the unimproved product. The authors did this with a spreadsheet. It is not in the interest of the higher priced firm (licensee) to cut supply (even though many of his units are unsold) because lower excess supply leads to lower actual sales at the high price. It is not in the interest of the lower priced firm

19. The context of product improvements adds an additional constraint, namely, that the licensee cannot have an incentive to switch to the unimproved product. That constraint is satisfied in the example.

(licensor) to increase supply because he loses some royalty as he crowds out sales of the licensee, and the price of his own units will fall. It is not in the interest of the licensee to supply the unimproved good instead or in addition to the improved good, because he would have to sell at a price that is lower than the licensor's price by Δ, and the sale would crowd out some of his sales at the higher, fixed price. ■

We now suppose that firm 2's improvement is both patentable and infringing. The natural cross licensing arrangement is with cross royalties. Let the cross royalties be (ρ_1, ρ_2), where ρ_1 is the royalty paid by firm 1 to the other and ρ_2 is the royalty paid by firm 2. The profit functions are

$$\begin{aligned}\underline{\pi}_1(q_1, q_u, q_2, \rho_1, \rho_2) &= q_1(1 + \Delta - q_1 - q_u - q_2 - \rho_1) \\ &\quad + q_u(1 - q_1 - q_u - q_2 - \rho_1) + q_2\rho_2 - \Gamma(q_1 + q_u) \\ \underline{\pi}_2(q_2, q_1, q_u, \rho_1, \rho_2) &= q_2(1 + \Delta - q_1 - q_u - q_2 - \rho_2) + q_1\rho_1 - \Gamma(q_2).\end{aligned}$$

An *equilibrium with cross royalties* (ρ_1, ρ_2) is (q_1, q_2), such that $\underline{\pi}_1(q_1, q_u, q_2, \rho_1, \rho_2) \geq \underline{\pi}_1(\hat{q}_1, \hat{q}_u, q_2, \rho_1, \rho_2)$ for all $\hat{q}_1, \hat{q}_u \geq 0$ and $\underline{\pi}_2(q_2, q_1, q_u, \rho_1, \rho_2) \geq \underline{\pi}_2(\hat{q}_2, q_1, q_u, \rho_1, \rho_2)$ for all $\hat{q}_2 \geq 0$.

Proposition 7. [Cross-Licensing with Royalties.] Suppose that the improvement is patented, but infringes the prior patent, and that the firms cross license with royalties (ρ_1, ρ_2). Suppose the marginal cost of supply satisfies $\gamma(q) = bq,\ b > 0$.

(a) If two licenses (ρ_I, ρ_2) and $(\hat{\rho}_I, \hat{\rho}_2)$ satisfy $\rho_I + \rho_2 = \hat{\rho}_I + \hat{\rho}_2$, then the corresponding equilibria satisfy $q_I + q_2 = \hat{q}_I + \hat{q}_2$. Furthermore, $\rho_I > \hat{\rho}_I$ implies $q_I < \hat{q}_I$ and $q_2 > \hat{q}_2$.

(b) If there is a license (ρ_I, ρ_2) that supports efficient production of the monopoly supply, then (22) and (12) hold.

$$\frac{1}{3 + b} \leq \Delta. \tag{22}$$

Proof. (a) Supposing that $\rho_1 \leq \Delta$, firm 1 supplies $q_u = 0$, and firm 1's and firm 2's equilibrium supplies (q_1, q_2) of the improved product satisfy

$$\begin{aligned}q_1 &= \frac{1}{2}[1 + \Delta - q_2 - \rho_1 - \gamma(q_1)] \\ q_2 &= \frac{1}{2}[1 + \Delta - q_1 - \rho_2 - \gamma(q_2)].\end{aligned}$$

These can be written

$$q_1 + q_2 = 1 + \Delta - \rho_1 - q_1 - \gamma(q_1) \tag{23}$$

$$q_1 + q_2 = 1 + \Delta - \rho_2 - q_2 - \gamma(q_2). \tag{24}$$

Hence

$$q_1 + q_2 = \frac{1}{3+b}[2(1+\Delta) - (\rho_1 + \rho_2)]. \tag{25}$$

Thus, if $\rho_1 + \rho_2 = \hat{\rho}_1 + \hat{\rho}_2$, the corresponding equilibria satisfy $q_1 + q_2 = \hat{q}_1 + \hat{q}_2$. In addition, it follows from equations (23) and (24) that $\rho_1 > \hat{\rho}_1$ implies $q_1 < \hat{q}_1$ and $q_2 > \hat{q}_2$. This proves (a).

(b) Condition (12) follows from equation (25), setting $q_1 + q_2 = q^*(\Delta) = 2(1+\Delta)/(4+b)$. The inequality (22) follows by adding the condition $\rho_1 = \rho_2 \leq \Delta$.

References

Adelman, Martin J., and Friedrich K. Juenger. 1975. "Patent-Antitrust: Patent Dynamics and Field-of-Use Licensing," 50 *New York University Law Review* 273–308.

American Bar Association Section of Antitrust Law. 2002. *The Federal Antitrust Guidelines for the Licensing of Intellectual Property: Origins and Applications*, 2nd ed. Chicago: ABA Publishing.

Areeda, Phillip E., and Herbert Hovenkamp. 2003. *Antitrust Law: An Analysis of Antitrust Principles and Their Application*. New York: Aspen Publishers.

Baxter, William. 1966. "Legal Restrictions on Exploitation of the Patent Monopoly: An Economic Analysis," 76 *Yale Law Journal* 267–370.

Bork, Robert H. 1965. "The Rule of Reason and the Per Se Concept: Price Fixing and Market Division," 74 *Yale Law Journal* 775–847.

———. 1978. *The Antitrust Paradox: A Policy at War With Itself*. New York: Basic Books.

Bowman, William S. 1973. *Patent and Antitrust Law: A Legal and Economic Appraisal*. Chicago: University of Chicago Press.

Chisum, Donald S. 2003. *Chisum on Patents: A Treatise on the Law of Patentability, Validity and Infringement*. Newark, NJ, and San Francisco: Matthew Bender & Co.

Furth, Helmut F. 1958. "Price-Restrictive Patent Licenses Under the Sherman Act," 71 *Harvard Law Review* 814–842.

Gifford, Daniel J. 2002. "The Antitrust/Intellectual Property Interface: An Emerging Solution to an Intractable Problem," 31 *Hofstra Law Review* 398–418.

Hovenkamp, Herbert, Mark D. Janis, and Mark A. Lemley. 2004. *IP and Antitrust: An Analysis of Antitrust Principles Applied to Intellectual Property Law*. New York: Aspen Publishers.

Kaplow, Lewis. 1984. "The Patent-Antitrust Intersection: A Reappraisal," 97 *Harvard Law Review* 1813–912.

Landes, William M., and Richard A. Posner. 2003. *The Economic Structure of Intellectual Property Law*. Cambridge, MA: Belknap Press of Harvard University Press.

O'Donoghue, Ted, Suzanne Scotchmer, and Jacques Thisse. 1998. "Patent Breadth, Patent Life and the Pace of Technological Progress," 7 *Journal of Economics and Management Strategy* 1–32.

Patterson, Mark R. 2002. "When is Property Intellectual: The Leveraging Problem," 73 *Southern California Law Review* 1133–60.

Rey, Patrick, and Jean Tirole. 2006. "A Primer on Foreclosure." In M. Armstrong and R. Porter, eds., *Handbook of Industrial Organization III*. Amsterdam: Elsevier (forthcoming).

Schlicher, John W. 2000. *Patent Law: Legal and Economic Principles*. Eagan, MN: Thomson/West.

Scotchmer, Suzanne. 1991. "Standing on the Shoulders of Giants: Cumulative Research and the Patent Law," 5 *Journal of Economic Perspectives* 29–41.

———. 2004. *Innovation and Incentives*. Cambridge, MA: MIT Press.

Shapiro, Carl. 2003. "Antitrust Limits to Patent Settlements," 34 *RAND Journal of Economics* 391–411.

Weinschel, Alan J. 2000. *Antitrust-Intellectual Property Handbook*. Little Falls, NJ: Glasser LegalWorks.

Case and Statutory References

Arthur J. Schmitt Foundation v. Stockham Valves and Fittings, Inc., 292 F. Supp. 893 (N.D. Ala. 1966).

California Dental Assn. v. FTC, 526 U.S. 756 (1999).

Carborundum Co. v. Molten Metal Equip. Innovations, Inc., 72 F.3d 872 (Fed. Cir. 1995).

Ethyl Gasoline Corp. v. U.S., 309 U.S. 436 (1940).

General Talking Pictures Corp. v. Western Electric Co., 305 U.S. 124 (1938).

Hensley Equip. Co., Inc. v. Esco Corp., 383 F.2d 252 (5th Cir. 1967).

Interstate Circuit v. U.S., 306 U.S. 208 (1939).

Morton Salt v. G.S. Suppiger Co., 314 U.S. 488 (1942).

Neal Report (White House Task Force Report on Antitrust Policy), *Antitrust & Trade Regulation Reports* 411 (Pt. 2) (1969).

Royal Industries v. St. Regis Paper Co., 420 F.2d 449 (9th Cir. 1969).

Shapiro v. General Motors Corp., 472 F. Supp. 636 (D. Md. 1979).

Statute of Monopolies, 21 Jam. I, c.3 (1623)(Eng.).
U.S. v. E.I. du Pont De Nemours & Co., 118 F. Supp. 41 (D. Del. 1953).
U.S. v. General Electric Co., 272 U.S. 476 (1926).
U.S. v. Line Material Co., 333 US 287 (1948).