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The Independent-Invention Defense in Intellectual Property[1]

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Abstract: Patents differ from other forms of intellectual property in that independent invention is not a defense to infringement. We argue that the patent rule is inferior in any industry where the cost of independently inventing a product is not too much less than (no less than half) the inventor's cost. First, the threat of entry by independent invention would induce patentholders to license the technology, lowering the market price. Second, a defense of independent invention would reduce the wasteful duplication of R&D effort that occurs in patent races. In either case, the threat of independent invention creates a mechanism that limits patentholders' profits to levels commensurate with their costs of R&D.

Keywords: patents, trade secrets, licensing, patent breadth

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1 Independent Invention

Perhaps the most basic difference between patents and other intellectual property like trade secrets and copyright is that independent invention is not a defense to infringement. If a firm inadvertently re-invents a patented technology, even an innocent attempt to market the product subjects the firm to damages and injunctions. This is not true of other forms of intellectual property, in which independent invention is either a recognized defense (*e.g.* trade secrets) or not protected against in the first place (*e.g.* copyright). It is hard to see how the two rules could simultaneously be optimal. In this paper we discuss industrial environments where the best rule is to allow a defense of independent invention. There are also circumstances in which the anomalous rule for patent cases may be superior, but those circumstances do not necessarily mirror legal doctrine; that is, they are not confined to intellectual property that is covered by patents.

Our argument has two prongs. One relates to how the market operates after a patent has issued, and the other relates to the race that leads to the patent. Regarding the *ex post* market, we argue that the threat of independent invention curbs market power without threatening the patentholder's ability to cover his R&D costs. Regarding the race, we argue that the defense of independent invention reduces waste.

Our argument is premised on the observation that, even if independent invention is legal, R&D costs will not necessarily be duplicated in equilibrium. Independent invention will be frequently threatened and rarely carried out. The patentholder will avoid duplication through licensing. The patentholder has an incentive to license on terms that commit to a low price, so that other potential duplicators are deterred. Such profit-eroding licensing is the patentholder's best option when he is threatened by duplication, and this is where the social benefit lies. Whether the patentholder can nevertheless cover his R&D cost depends on the cost of duplication. Lower costs of duplication will lead to a more generous licensing policy, and less profit for the patentholder. However in the (standard) model we present, the duplicator's costs can be as little as half those of the patentholder, without jeopardizing the patentholder's incentives to innovate.

Our scheme thus addresses an important criticism of the existing patent system, namely, that the market power conferred by a patent does not take account of the R&D cost. Under the current system, if the value of the invention is very large relative to R&D cost, then the inventor may be overrewarded, and deadweight loss may be unnecessarily high. But if independent invention is a defense to infringement, the patentholder limits his own market power by allowing entry. Provided the cost of independent invention is not too much lower than the original cost of invention, the prospect of allowing entry will not undermine his own incentives to invent.

The race leading up to the patent is another matter. The race might lead to duplicated R&D costs with or without the threat of independent invention. However we argue that the problem is mitigated by a defense of independent invention.

The same analysis can be interpreted for "inventing around" a patent. Whether an entrant enters by independently inventing a close substitute or by avoiding the patent in his production process, his incentive to enter, and his impact on the patentholder's profit, depend only on the cost of entry. If breadth is related to the costs of entry, then "breadth" requirement for patents serves the same role as the "independence" requirement for trade secrets and copyrights, and similar economic analysis applies. We apply our arguments to this interpretation, and, in doing so, address a disagreement between Gilbert and Shapiro (1990) and Gallini (1992).

In the next section we illuminate the patentholder's *ex post* incentive to commit to lower prices through licensing, in order to avoid duplication.[4] In Section 3, we show

[4]Many legal scholars have been less optimistic than economists about whether firms will license to avoid waste. E.g., see Adelman (1977) who thinks not, and suggests that rights should reflect this problem. In contrast, Lichtman (1997) makes an argument in the spirit of our own paper, but for unpatentable goods. His model is most easily interpreted as one in which entrants serve different

how the threat of duplication affects patent races. Part of this argument is similar to that of La Manna, MacLeod and de Meza (1989), although they did not discuss the independent invention defense. In Section 4 we point out that a suitable patent breadth can lead to social benefits similar to those engendered by the defense of independent invention, and we resolve the previous dispute. In Section 5 we discuss the limitations of our arguments, and the dangers inherent in making independent invention a defense. In particular we address the feasibility of the independent invention defense for patents, and point out circumstances where the defense would be hard to implement.

The innovation and licensing markets in this paper operate differently than those of Gallini (1984) and Gallini and Winter (1985) because of the threat of entry. Those papers focussed on cost-reducing innovations in two-firm markets with no threat of additional entry. In this paper it is the continual threat of entry by as yet unidentified entrants that induces the patentholder to commit to a lower market price through licensing. With no threat of entry, the licensor would want to to keep price high rather than low. The threat of entry gives the patentholder an incentive to limit his own profit in exactly those circumstances where profit can be limited without undermining the incentive to innovate.

2 A Model with No Patent Race

First we assume that a single patent has issued, and show how the defense of independent invention can motivate licensing in order to deter entry. Licensing reduces the market price and benefits consumers without jeopardizing the patentholder's ability to recover R&D costs. In the next section, we introduce a patent race in the same model.

The market game after issuance of the patent is as follows. A patentholder has a

markets, since there are no price effects.

proprietary product that can be independently duplicated at the cost K^E. We let K^P represent the cost that the patentholder himself invested in the innovation. If the patentholder licenses the technology, he will license with a fixed fee and royalty, (F, ρ), to the maximum number of firms, n, that would find it profitable to enter on those terms. The market price of the patented commodity will depend on the number of licensees and their marginal costs of production, where "marginal cost" includes any royalties they must pay. Since all firms who enter the market, whether by license or duplication, will have the same technology, their "marginal costs" of production will be either c (for the patentholder and possibly an entrant who duplicates the technology) or $c+\rho$ (for a licensee). There will be n market participants with "marginal cost" $c+\rho$ and k participants with marginal cost c. With no entrants, $k = 1$ (the patentholder), and with entry, $k = 2$ (the patentholder plus entrant). In equilibrium, $k = 1$, since the licensing strategy will deter entry. Our objective is to characterize the licensing strategy, n and (F, ρ), that maximizes profit subject to deterring entry, and to show that if demand is "large" relative to R&D costs, the patentholder will undermine his own profit by licensing to several firms at a reasonable royalty rate, after which he earns less than the monopoly profit.

We let $\Pi^P(n, \rho)$ represent the sum of licensees' and patentholder's profit. We assume that all the profit $\Pi^P(n, \rho)$ is collected by the patentholder through the fixed fee F, and the licensees make zero profit. It is optimal for the licensees to accept such terms because, in equilibrium, the royalty rate will be chosen so that entry is deterred. Assuming that there are an unlimited number of potential licensees and entrants, a licensee cannot make positive profit by refusing the license and duplicating the invention. Another licensee would take his place, and then he would not find it profitable to duplicate the invention and enter without a license. Thus the licensee cannot do better than to accept the licensing terms that give him zero profit.

Because of the threat of entry, the patentholder will not charge the monopoly price. Instead he will use licensing to commit to a lower market price in order to deter entry.

Of course licensing is only optimal if the costs of R&D (and costs of duplication) are relatively low; otherwise entry is not a threat, and, indeed, the patentholder might need the whole monopoly profit to cover his R&D costs. But when the R&D costs (and costs of duplication) are low, the threat of entry can improve consumer welfare without reducing incentives to innovate.

We now make the described model more specific by assuming a linear demand curve and Cournot competition. Suppose the inverse demand function is given by the function $q \mapsto a - q$, $a > 0$, and the marginal cost of production is c, $c < a$. In Cournot equilibrium, $q^L(n, \rho, k)$ and $q^C(n, \rho, k)$ are respectively the quantities supplied by each licensed firm and each unlicensed firm. They solve:

$$\begin{aligned} q^L(n,\rho,k) &= \arg\max_q \; [a - ((n-1)q^L(n,\rho,k) + q + kq^C(n,\rho,k))]\; q - (c+\rho)\; q \\ q^C(n,\rho,k) &= \arg\max_q \; [(a - (nq^L(n,\rho,k) + (k-1)q^C(n,\rho,k) + q)]\; q - c\; q \end{aligned}$$

The solutions are

$$q^C(n,\rho,k) = \frac{a-c}{n+k+1} + \frac{n\rho}{n+k+1}$$

$$q^L(n,\rho,k) = \frac{a-c}{n+k+1} - \frac{(k+1)\rho}{n+k+1}$$

$$p(n,\rho,k) = a - n\; q^L(n,\rho,k) - k\; q^C(n,\rho,k) \; = a - [\frac{n+1}{n+k+1}(a-c) - \frac{n}{n+k+1}\rho]$$

$$\Pi^P(n,\rho) = [p(n,\rho,1) - c]\; [n\; q^L(n,\rho,1) + \; q^C(n,\rho,1)]$$

$$= \frac{1}{(n+2)^2}\; [a - c + n\rho]\; [(n+1)(a-c) - n\rho] \qquad (1)$$

We now consider the profitability of entry. Let $\Pi^E(n,\rho)$ designate the profit of an entrant into a market with n licensees paying royalty ρ. The value of $\Pi^E(n,\rho)$ below reflects the assumption that subsequent to entry the firms achieve a Cournot equilibrium with one additional unlicensed firm.

$$\Pi^E(n,\rho) \;=\; [p(n,\rho,2)-c]\; q^C(n,\rho,2) \;=\; \frac{1}{(n+3)^2}\,(a-c+n\rho)^2 \tag{2}$$

Lemma 1 *If the patentholder licenses his technology, the optimal royalty rate satisfies* $\rho < \frac{a-c}{3}$.

Proof: We consider two cases, $K^E > \frac{1}{9}\,(a-c)^2$ and $K^E \leq \frac{1}{9}\,(a-c)^2$. In the first case, where the duplication costs are relatively high, the patentholder will not license. If an entrant competes with the patentholder in the absence of licensees, each firm earns the duopoly profit $(a-c-2q^C(0,0,2))q^C(0,0,2) = \frac{1}{9}\,(a-c)^2$. No licensees are needed in order to deter entry. Consider the second case. The expression for $q^L(n,\rho,k)$ shows that licensees will not produce in equilibrium unless the royalty rate satisfies $\rho < (a-c)/(k+1)$. To help deter entry, the licensees must be willing to supply a positive amount after entry, when $k = 2$. Otherwise the patentholder and entrant would again earn duopoly profits $\frac{1}{9}\,(a-c)^2$, which would not deter entry. The result follows. □

In view of this lemma, let Π^P and Π^E be defined on the domain $R_+ \times [0, \frac{a-c}{3}]$. On this domain, $\Pi^E(\cdot,\rho)$ is decreasing at each fixed ρ, and $\Pi^E(n,\cdot)$ is increasing at each fixed n. (At a fixed royalty, a potential entrant's profit is a decreasing function of the number of licensees. With a fixed number of licensees, the potential entrant's profit increases with the royalty.)

The arguments that now follow can most easily be understood if the reader refers to Figure 1. The patentholder's profit (the upper lines) and the profit of a prospective

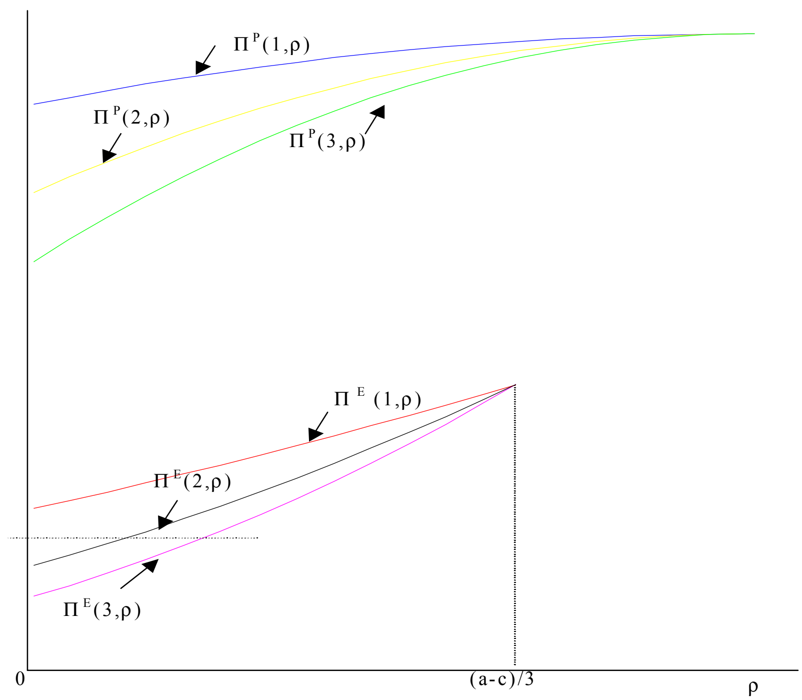

Figure 1:

entrant (the lower lines) are graphed for $n = 1, 2, 3$. As one can see, the patentholder's profit is approximately twice the entrant's profit, for each (n, ρ). If the cost of entry would be K^E, as shown by the horizontal dotted line, then entry can be deterred with $n = 2$ or $n = 3$ licensees. With 2 licensees, the patentholder will increase the royalty ρ to the intersection of the dotted line with the line that represents $\Pi^E(2, \rho)$.

In the following Lemma, Z_+ represents the positive integers.

Lemma 2 *For each* K^E, $0 < K^E < \frac{1}{9}(a-c)^2$ *there exists* $(n, \rho) \in Z_+ \times\ [0, \frac{a-c}{3}]$ *such that* $\Pi^E(n, \rho) = K^E$.

Proof: First observe that $\Pi^E(\cdot, 0)$ is decreasing and continuous in its argument $n \in R_+$, and that $\Pi^E(\cdot, 0)$ takes every value in $(0, \frac{1}{9}(a-c)^2)$ for some nonnegative value n. Hence there exists $n^* \in R_+$ that satisfies $\Pi^E(n^*, 0) = K^E$. However n^* might not be an integer. Let $\tilde{n}$ be the smallest integer that is no smaller than n^*. It holds that $\tilde{n} \geq n^*$, and typically $\tilde{n} > n^*$. Since $K^E < \frac{1}{9}(a-c)^2$, it follows that $n^* > 0$ and $\tilde{n} \geq 1$. Since $\Pi^E(\cdot, 0)$ is decreasing, $\Pi^E(\tilde{n}, 0) \leq K^E$. Using continuity of $\Pi^E(\tilde{n}, \cdot)$, since $\Pi^E(\tilde{n}, 0) \leq K^E = \Pi^E(n^*, 0) \ < \Pi^E(\tilde{n} - 1, 0) \leq \Pi^E(\tilde{n}, \frac{\alpha - c}{3})$, there exists $\rho \in [0, \frac{a-c}{\rho}]$ such that $\Pi^E(\tilde{n}, \rho) = K^E$. $\square$

Lemma 3 *For every* $n \geq 0$ *and* $\rho \leq \frac{a-c}{3}$, $\frac{\Pi^P(n,\rho)}{\Pi^E(n,\rho)} > 2$.

Proof: Using (1) and (2),

$$\frac{\Pi^P(n, \rho)}{\Pi^E(n, \rho)} = \frac{(n+3)^2}{(n+2)^2} \left(\frac{(a - c + n\rho)\ (\ (n+1)(a - c + n\rho) - (n+2)n\rho)}{(a - c + n\rho)^2} \right)$$

$$= \frac{(n+3)^2}{(n+2)^2} \left((n+1) - \frac{(n+2)n\rho}{(a - c + n\rho)} \right)$$

Since the last line is decreasing in ρ, and using $\rho \leq \frac{a-c}{3}$,

$$\frac{\Pi^P(n,\rho)}{\Pi^E(n,\rho)} \geq \frac{(n+3)^2}{(n+2)^2}\left((n+1) - \frac{(n+2)n}{(n+3)}\right) = \frac{(n+3)(2n+3)}{(n+2)^2}$$

But since the righthand side expression is decreasing in n, this implies(taking the limit as $n \to \infty$) that $\frac{\Pi^P(n,\rho)}{\Pi^E(n,\rho)} > 2$. $\square$

The following proposition is the main result on *ex post* licensing. It implies that if the costs of duplication are more or less commensurate with the original innovator's costs, $K^E = K^P$, then incentives to innovate are not threatened by the threat of duplication. In fact the costs of duplication can be lower than the innovator's costs, by as much as half.

Proposition 1 *Let $K^E \geq \frac{1}{2}K^P$. Then there exists a licensing contract (n,ρ) such that (i) entry by independent inventors is deterred, $\Pi^E(n,\rho) \leq K^E$, and (ii) the innovator covers his costs: $\Pi^P(n,\rho) > K^P$.*

Proof: Suppose first that $K^E > \frac{(a-c)^2}{9}$. Then entry is deterred without licensing, since the the duopoly profits will not cover the imitator's costs.

Therefore suppose that $K^E \leq \frac{(a-c)^2}{9}$. By Proposition 2, there exists a licensing contract (n,ρ) such that $K^E = \Pi^E(n,\rho)$. Using Lemma 3, $\Pi^P(n,\rho) > 2\Pi^E(n,\rho) = 2K^E > K^P$. $\square$

3 Patent Races

We now ask how the independent-invention rule affects a patent race. Suppose, first, that the race is winner-take-all, as usually conceived. Then by the arguments above, the *ex post* value of the patent will be reduced by lenient license terms to a value close to the cost of R&D. In anticipation of this, entry to the race will be limited, perhaps to one firm. Thus, the threat of independent invention might substantially reduce the cost duplication in a race.

However the defense of independent invention might alternatively support the view that the firms in the race are independent inventors (none learned the technology from another firm), so that each successful firm can enter the market at the end of the race. This scenario is similar to the permissive-patents regime suggested by La Manna, MacLeod and de Meza (1989). The firms in the race will become market competitors, just as if they had been racing for a trade secret rather than a patent.[5]

Our conclusion below is that the threat of *ex post* competition will deter some firms from entering the race. The *ex post* competition reduces the market price, and the *ex ante* reluctance to race reduces the duplication of R&D costs. Both effects improve social welfare.

We will use the notation $\Pi^o(k)$ for per-firm profit in an oligopoly with k firms. The total profit available to k firms competing in the market is $k\Pi^o(k)$. Our argument depends only on the fact that, with constant marginal costs of production, $k\Pi^o(k)$ is less than the monopoly profit $\Pi^o(1)$ (else the monopolist would choose the oligopolists' price). Although nothing in the argument depends on the specifics of the above model, the value of $\Pi^o(k)$ in the above model is

$$\Pi^o(k) = \left[a - kq^C(0,0,k) - c\right] q^C(0,0,k) = \frac{1}{(k+1)^2}(a-c)^2$$

We assume that several firms can simultaneously invest the R&D cost K^P in pursuit of the patent. Under the current rule, where independent invention is not a defense,

[5] It does not matter whether all the firms in the race receive patents, or whether the first inventor receives the patent, and the other independent inventors only receive a defense against infringement. In both cases, enough firms will race so that there is no temptation to duplicate after the patent issues.

one patent will issue, and only one firm will be authorized to sell in the market. If there are k firms in a race, each wins the patent with probability $\frac{1}{k}$, so the expected value of entering the race is $\frac{1}{k}\Pi^o(1) - K^P$. The total amount invested in the race is kK^P, of which $(k-1)K^P$ is unnecessary cost duplication. The following proposition says that the independent-invention rule can reduce the cost duplication.

Proposition 2 *Assume that marginal costs of production are constant, so that total profit of firms in an oligopoly with $k > 1$ firms is less than in a monopoly,* i.e., $k\Pi^o(k) < \Pi^o(1)$. *Under the rule that independent invention is a defense to infringement, there is less (no greater) duplication of costs in a patent race than with the alternative rule, where only one firm can enter the market* ex post*, and is immune from duplication.*

Proof: If independent invention is not a defense, then the number of firms $\bar{k}$ in the race solves $\Pi^o(1)/\bar{k} \geq K^P > \Pi^o(1)/(\bar{k}+1)$. This means that each firm in the race makes nonnegative expected profit, and the firms would make negative expected profit if another entered the race. If independent invention is a defense, then the number of firms $\tilde{k}$ in the race solves $\Pi^o(\tilde{k}) \geq K^P > \Pi^o(\tilde{k}+1)$. Thus, $\Pi^o(1)/(\bar{k}+1) < K^P \leq \Pi^o(\tilde{k})$, so $\Pi^o(1) < (\bar{k}+1)\Pi^o(\tilde{k})$. But then $\tilde{k}\Pi^o(\tilde{k}) < \Pi^o(1) < (\bar{k}+1)\Pi^o(\tilde{k})$, so $\tilde{k} < \bar{k}+1$, or $\tilde{k} \leq \bar{k}$. □

Even though the defense of independent invention can reduce the duplication of R&D costs in a race, the wasteful duplication might not be eliminated entirely. There will be enough firms in the market *ex post* so that no licensing is required to deter further duplication. This is because an *ex post* entrant would earn $\Pi^o(\tilde{k}+1) - K^P < 0$.

Nevertheless, the patent race itself remains wasteful. If there were a fixed number of potential entrants to the race, the identified potential entrants could form a joint venture to eliminate the duplication, sharing the *ex post* profit. However the assumption of unlimited potential entrants makes this impossible, since there will always be another potential entrant ready to race against the joint venture.

4 Patent Breadth as a Policy Instrument

Even though there is currently no defense of independent invention, firms can still "duplicate" inventions by inventing around existing patents. To invent around a patent, the imitator must make sure his imitation falls outside the patent's *breadth*.[6] There is no concept of breadth for either trade secrets or copyrights, and consequently there is no defense of "independence" if the imitator had access to the invention. Patents automatically give access through disclosure, and that is why a certain amount of breadth is a necessary feature of patent protection.

Exactly as in the story above, a patentholder will have incentive to license potential entrants in order to avoid the costs that might be wasted in inventing around a patent. He thus makes the best of a bad prospect. This leads to the social benefits described above, namely, that the patentholder will give terms that reduce the market price in order to deter entry. As long as the cost of duplication is high enough, the patentholder will nevertheless cover his costs.

In this interpretation, our arguments shed light on optimal patent breadth, and in particular on a disagreement between Gilbert and Shapiro (1990) and Gallini (1992). Gilbert and Shapiro (1990) interpret patent breadth as a constraint on how high a monopolist can raise price, holding the market demand fixed. This is unsatisfactory because there is no legal interpretation under which narrowing patent breadth would have the effect of lowering price while keeping the demand fixed.[7] A more convincing notion of breadth was given by Gallini (1992), who interpreted breadth as the amount of investment required to invent around the patent. Given a fixed term of protection,

[6]Patent breadth governs other economic functions as well as limiting horizontal entry. See, e.g., Klemperer (1990), where breadth used to define distance between protected and imitation products in quality space; Green and Scotchmer (1995) and O'Donoghue, Scotchmer and Thisse (1998), where breadth determines whether a new product infringes an old patent in the context of cumulative innovation, and Hopenhayn and Mitchell (2001), who show in such a model that it might be optimal to differentiate patent breadths by endogenous choice.

[7]The authors refer to compulsory licensing, but that is a weak argument, since the U.S. has no such thing, and in any case, it is not the same as patent breadth.

a narrow enough patent encourages entry, reduces the market price, and erodes the patentholder's profit. It is thus an interpretation under which narrower breadth has an impact on price without changing demand. Gallini concludes, however, that patents should be broad enough to prevent entry, as the duplication of costs required for entry is socially wasteful.

These two papers reach opposite conclusions about whether patents should be long and narrow or short and broad. Gilbert and Shapiro are concerned only with minimizing discounted deadweight loss, and conclude that patents should be long and narrow. However Gallini is concerned with minimizing deadweight loss plus wasteful expenditures. The goal of avoiding waste leads her to conclude that patents should short and broad (just long enough so the patentholder covers his costs, and broad enough to deter entry).

We disagree with both these analyses. The Gilbert and Shapiro analysis does not have a mechanism by which breadth affects price, and the Gallini analysis does not hold if patentholder and potential entrants do what is rational, namely, license to avoid waste. In fact, using the Gallini definition of breadth, the analysis above can be used to restore the Gilbert and Shapiro analysis. A narrower patent (lower costs of entry) encourages licensing on terms that lead to a lower market price without duplicative waste. Thus, breadth is monotonically related to price, as assumed by Gilbert and Shapiro. Since there is no duplicative waste in equilibrium, their type of analysis is restored.

Of course the limitations of the Gilbert and Shapiro treatment remain. Whether long, narrow patents are superior to short, broad patents depends on market considerations such as the shape of the demand curve. Further, Gilbert and Shapiro implicitly impose a regulatory burden to regulate the monopolist's price according to his R&D costs. Similarly, the interpretation here imposes a burden to tailor patent breadth to R&D costs. These burdens would be largely avoided by forcing a lower price through the independent-invention defense.

5 Robustness

We now address some of the limitations and dangers inherent in the independent-invention defense.

Would Independent Inventors Have a Significant Cost Advantage?

Our argument works if the cost of duplication is not much lower than the patentholder's R&D cost of invention. (Some discrepancy can be tolerated; see Figure 1.) There are two basic reasons that the costs of duplication can be lower. First, merely knowing that someone has invented a product can be important for expected costs of duplication in cases where significant *ex ante* doubts exist about whether the proposed product can be made at all. (The atomic bomb is a particularly notorious example.) Second, competitors can cheat by claiming that they independently invented what they surreptitiously copied. We discuss the first possibility here and address cheating in the next subpart.

Pharmaceuticals are probably the best example of an industry with significant *ex ante* uncertainty about success. The probability of achieving a marketable, FDA-approved drug is about 1/5, conditional on having sunk the development costs. If the cost of every pharmaceutical that comes to market is $.2b, firms must anticipate $1b in revenues in order to cover costs on average. The effective cost of each new drug is therefore $1b, since this is the minimum compensation needed to induce firms to invest. On the other hand, an independent invention defense could let imitators avoid "dry holes" and cut their R&D costs by 80%. In such a case, the threat of duplication would undermine the patentholder's profit to the point where he could no longer cover his costs.

Pharmaceuticals are clearly important, but it is unclear how typical the phenomenon is. In most industries, the question of whether a particular invention is possible given sufficient time and investment is never in doubt. (Automobiles, airplanes, computer hardware, and software are good examples.) The real trick is to avoid blind alleys so that the new product can be delivered on time and under budget. Knowing that the original inventor has found a workable solution does little or nothing to avoid these pitfalls. An independent invention defense therefore makes sense in such industries.

There are various legal methods to distinguish these situations. For example, one could imagine that in cases with significant *ex ante* uncertainty of success (*e.g.*, pharmaceuticals), judges would rule that independence is impossible. Hence the defense would not apply. Imitators would have to invent around the patent. Our analysis suggests that courts should set patent breadth so that the costs of imitation approximate the original inventor's effective cost averaged over an appropriate number of dry holes.

Alternatively, one could imagine legislators enacting an independent invention defense with listed exceptions for special-case industries like pharmaceuticals.[8]

Can independent inventors cheat?

Despite its theoretical advantages, an independent-invention defense could still turn out to be unenforceable. This may explain why patent law has always lacked such a defense, even though there is a such a defense in copyright and trade secrecy law. Since patents are (by definition) in the public domain, fraudulent claims of independence may be undetectable. For copyright, illicit copying can usually be detected by examining the infringing product itself, and for trade secrets, there is usually a trail of wrongful acts that led to a breach of security.

It is possible that the historic justification no longer applies. Cheating of the intentional variety can be controlled. Companies faced with potential intellectual

[8]This trend is growing. Special intellectual property legislation already exists for drugs, microprocessor chips, and even boat hulls.

property disputes routinely sequester their engineers in “clean rooms” before telling them what to develop, especially when it comes to software, which is now patented as well as copyrighted. Clean rooms can also be used to reduce the risks of unconscious cheating, as when a software developer unconsciously appropriates knowledge that he wishes he had not seen.

The risk of cheating is present in all legislation; the real question is whether the risk is manageable. If clean rooms were the norm, firms would have strong incentives to (a) implement ’zero tolerance’ precautions against conscious cheating, and (b) select and isolate clean room personnel before unconscious cheating became a significant risk. This is because they would know that even the tiniest irregularities could persuade a jury to deprive them of their investment.

Does the form of competition matter?

So far, our arguments have assumed that firms are Cournot competitors. As elaborated by Singh and Vives (1984), also Häckner (2000), Bertrand competition and Cournot competition generally lead to different prices and profits. The authors consider both substitutes and complements, but for our purposes, it is mainly substitutes that matter, as complementary products would not generally infringe the original patent, whether or not they were independently invented.

A key finding is that, when the products are substitutes, Bertrand competition reduces prices and profits. If the firms anticipate Bertrand competition, entry will more likely be deterred. In fact, entry may be so strongly deterred in the first case we considered, where only one firm would invest in the patent, that there is no reason to license. The salutary effects of price reductions through licensing vanish. Paradoxically, the threat of a price war after entry will lead to higher prices in equilibrium than under Cournot competition. With entry deterred by the threat of Bertrand competition, the innovator could cover his costs with an even bigger cost discrepancy than described in Proposition 1.

However, independent invention still improves efficiency for Bertrand competition under our patent race model, at least in the case that all innovators can participate in the market. Fewer firms will race, and wasteful duplication will be reduced. Under the alternative rule, where several firms may race for the patent but only one patent will issue, the form of ex post competition does not matter.

Are patent races beneficial?

A final reason for caution relates to an old ambiguity about the efficiency of patent races. Following, for example, Wright (1983), we have taken the view that patent races permit an inefficient duplication of costs and should be avoided. However other authors (for example, Loury (1979)) take the view that patent races can be efficient because, although they increase R&D costs, they also accelerate innovation, which has offsetting benefits. The model here cannot address that view because the costs of R&D are lump sum, and the timing of innovation is not at issue. If greater rewards lead to faster invention, the existence of an independent-invention defense could inefficiently retard innovation by lowering the patentholder's profit.

6 Conclusion

Our argument in favor of independent invention as a defense to infringement considers two cases. First, the threat of duplication after the patent issues leads to lower market price and less deadweight loss. Licensing will reduce market price in a way that benefits consumers without threatening the incentives to innovate. Since duplication will not actually take place, the threat improves efficiency.

Second, the independent-invention defense reduces entry into the race, and thus reduces wasteful duplication. If the race is winner-take-all, as usually conceived under existing law, then the prospect of having to license *ex post* in order to avoid duplication will limit the number of firms in the race. Under the alternative rule where all successful firms in a race can enter the market *ex post*, then *ex post* competition among successful inventors will keep the consumer price lower than under the alternative rule, where independent invention is not a defense. Both consequences – lower prices in the market and less waste in a race – improve efficiency without jeopardizing innovation.

With low costs of duplication, a very low market price is required to deter entry, and the patentholder does not recover his R&D costs. This is why we require that the entrant "duplicate" the invention rather than "copy" it. It is also why, in industrial contexts where the imitator can avoid dry holes by observing what products were successful, duplicated inventions should not be interpreted as "independent."

The assumption that the cost of imitation must be as high as the original R&D costs can be somewhat relaxed, and therefore the theory can tolerate some imprecision in the interpretation of independence. In equilibrium, the patentholder makes more profit than a duplicating firm could make (see Figure 1), and the patentholder can therefore recover costs while still deterring entry even if the duplicating firm has some cost advantage.

References

[1] ADELMAN, M.J., (1977), Property Rights Theory and Patent-Antitrust: The Role of Compulsory Licensing," 52 *N.Y.U. Law Review* **977**, 982 (1977).

[2] GALLINI, N. T. (1984), Deterrence by Market Sharing: A Strategic Incentive for Licensing", *American Economic Review* **74**, 931-941.

[3] GALLINI, N. T. AND R. WINTER (1985), Licensing in the theory of Innovation", *The Rand Journal of Economics* **16**, 237-252.

[4] GALLINI, N. T. (1992), Patent Policy and Costly Imitation", *The RAND Journal of Economics* **44**, 52-63.

[5] GILBERT, R. AND C. SHAPIRO (1990), Optimal Patent Length and Breadth", *The RAND Journal of Economics* **21**, 106-112.

[6] GREEN, J. AND S. SCOTCHMER (1995), 'On the Division of Profit in Sequential Innovation', *The Rand Journal of Economics* **26**, 20-33.

[7] HACKNER, J. (2000), A Note on Price and Quantity Competition in Differentiated Oligopolies", *Journal of Economic Theory* **93**, 233-9.

[8] HOPENHAYN, H. AND M. MITCHELL (2001), Innovation Variety and Patent Breadth", *the RAND Journal of Economics* **32**, 152-166.

[9] KLEMPERER, P. (1990), How Broad Should the Scope of Patent Protection Be?", *The RAND Journal of Economics* **21**, 113-130.

[10] LA MANNA, M., R. MACLEOD AND D. DE MEZA (1989), The Case for Permissive Patents", *European Economic Review* **33**, 1427-1443.

[11] LICHTMAN, D. (1997) The Economics of Innovation: Protecting Unpatentable Goods," 81 *Minn. L. Rev.* **693**, 721-23.

[12] LOURY, G. C. (1979) Market Structure and Innovation", *Quarterly Journal of Economics* **93**, 395-410.

[13] O'Donoghue, T., S. Scotchmer and J.-F. Thisse (1998), Patent Breadth, Patent Life and the Pace of Technological Progress", *Journal of Economics and Management Strategy* **7**, 1-32.

[14] Singh, N. and X. Vives (1984), Price and Quantity Competition in a Differentiated Duopoly", *RAND Journal of Economics* **15**, 546-54.

[15] Wright, B. (1983), The Economics of Invention Incentives: Patents, Prizes and Research Contracts, *American Economic Review* **73**, 691-707