

**INTELLECTUAL PROPERTY AND INNOVATION:
THEORETICAL, EMPIRICAL, AND HISTORICAL PERSPECTIVES***

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This paper examines from various angles the complex relationship between intellectual-property rights and technological innovation. Part I summarizes the principal economic theories concerning how intellectual-property systems can stimulate or impede technological progress. Part II discusses the extent to which those theories find support in the histories in the United States of four technology-intensive industries: pharmaceutical products; biotechnology; aviation; and computer software. The Conclusion attempts to extract from those four historical case studies some generalizations concerning when and how intellectual-property rights might sensibly be employed to foster innovation.

I.

We begin with some familiar generalizations: Technological innovations belong to the category of objects and services that economists refer to as “public goods.” The distinctive characteristics of public goods are that they can be replicated easily and that they are “nonrivalrous” – in other words, enjoyment of them by one person does not prevent enjoyment of them by other persons. Those characteristics in combination create a danger that the pace of technological innovation will fall below socially optimal levels. Why? Because potential innovators will know that, once they reveal their breakthroughs to the world, other people will be able to take advantage of them for free. Consequently, the innovators will be unable to recoup the costs of their innovations (the costs of the education they underwent to prepare them to make the innovations, the outlay for research and development, their opportunity costs, etc.). Aware of this risk, potential

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innovators will devote their energies to other, more lucrative activities, and society at large will suffer.¹

There are five main strategies that can be employed by governments that wish to avoid this undesirable outcome. First, governments can engage in technological innovation themselves. With respect to many other sorts of public goods – such as lighthouses and national defense – governments for centuries have responded to the risk of suboptimal private-sector production by supplying the relevant objects or services themselves. (Notice, for example, that virtually all navigational aids and virtually all armies throughout the world are now supplied and maintained by governments, not private parties.) The same strategy can be employed in the context of technological innovation. In the United States, government research conducted under the auspices of the National Institutes of Health, the Department of Agriculture, and the National Aeronautics and Space Administration represent manifestations of this approach.

Second, governments can subsidize innovative activities by private actors. In the United States, the grants given to artists by the National Endowment for the Arts and the grants given to private universities and individual researchers by the National Institutes of Health exemplify this approach.²

Third, governments can issue *post-hoc* prizes or rewards to persons and organizations that provide the public socially beneficial innovations. The lure of such rewards is intended to offset, in whole or in part, the disincentive to engage in innovative activity created by the public-goods phenomenon. Although several private institutions (most notoriously, the Nobel Foundation) employ this strategy, use of this tactic by governments currently is relatively rare. In the past, however, the government of the United States considered using it much more extensively.³ In a recent paper, Steven

¹This argument is developed in Jeremy Bentham, *A Manual of Political Economy* (New York: Putnam, 1839); John Stuart Mill, *Principles of Political Economy*, 5th ed. (New York: Appleton, 1862); A.C. Pigou, *The Economics of Welfare*, 2d ed. (London: Macmillan & Co., 1924); and William Landes & Richard Posner, "An Economic Analysis of Copyright Law," *Journal of Legal Studies* 18 (1989): 325.

² The details of this strategy are explored in Part II.B., below.

³ See Edward C. Walterscheid, "To Promote The Progress Of Science And Useful Arts: The Background And Origin of The Intellectual Property Clause of The United States Constitution," *Journal of Intellectual Property Law* 2 (1994): 1.

Shavell and Tanguy van Ypersele outline and recommend a comprehensive system of this sort, under which “innovations would pass immediately into the public domain, becoming freely available to all,” and the innovators would then receive from the state periodic payments (derived from general tax revenues) reflecting the social value of their creations.⁴

Fourth, in some contexts governments can help innovators to conceal from the public information essential to implement their innovations, thus increasing their ability to charge persons who wish to take advantage of those breakthroughs. The most familiar and important example of this strategy is trade-secret law.⁵ Among the less well-known applications of this approach were statutes adopted by some American states that forbade a particular type of reverse engineering of vessel designs, thereby compelling competitors to use more circuitous ways of learning and copying the dimensions of novel boats.⁶

The fifth and last of the strategies is the one upon which the remainder of this paper will concentrate: Governments may confer intellectual-property rights upon innovators. In other words, governments may grant to innovators exclusive rights to engage in certain kinds of activities with respect to their innovations – for example, the rights to “make, use, or sell” objects embodying them;⁷ to “reproduce” them; or to prepare “derivative works” from them.⁸ Entitlements of these sorts enable innovators to charge persons who wish to obtain access to their creations, thus enabling innovators both to recoup the costs of innovation and to make a profit on their activities.

⁴ More specifically, Shavell and Ypersele contend that a regime in which, after an invention had been commercialized, the government used sales data and surveys to assess its social value and then periodically paid the inventor accordingly might be better, despite the familiar difficulties associated with governmental estimates of this sort, than a patent regime – and that a system in which each inventor had the option of either obtaining a traditional patent or collecting the government’s reward would certainly be better than a simple patent system. See “Rewards versus Intellectual Property Rights,” NBER Working Paper No. W6956 (1999), available at: <http://papers.nber.org/papers/W6956>.

⁵ The best analyses of the economic advantages and disadvantages of this approach are Robert Bone, “A New Look at Trade Secret Law: Doctrine in Search of Justification,” *California Law Review* 86 (1998): 241; and Adam Wichman, “Economic Analysis of Trade Secret Law” (unpublished paper, March 26, 2001).

⁶ Such statutes were declared preempted by patent law in *Bonito Boats, Inc. v. Thunder Craft Boats, Inc.*, 489 U.S. 141 (1989). The resultant gap in the protections enjoyed by novel vessel designs has now been filled (in a different way) by 17 U.S.C. §§1301-1332.

⁷ See 35 U.S.C. §271(a).

None of these five strategies is perfect; each one has both advantages and disadvantages. As will be seen in Part II of this paper, governments have in practice relied on the five approaches to different degrees in different industrial contexts. In deciding whether and how to employ the fifth strategy, the potential availability of the other four approaches should always be considered. With that cautionary guideline in mind, we turn to an examination of the particular merits and demerits of intellectual property.

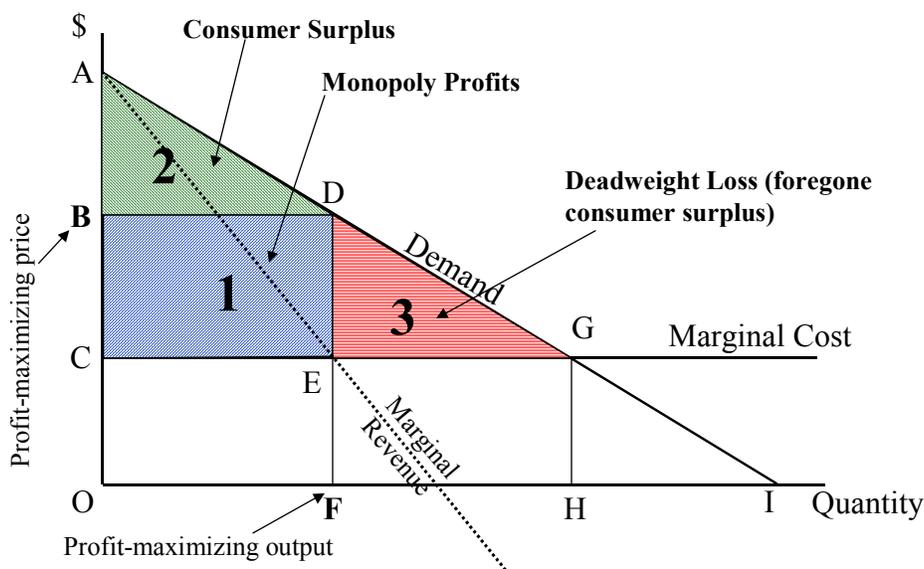
Three sets of theoretical considerations complicate the use of intellectual-property rights to stimulate innovation. These are summarized below (in approximate order of importance).

A.

Intellectual-property rights have the following unfortunate side effects: (1) They are costly to administer. The establishment and maintenance of patent registration systems, the staffing of courts to interpret and enforce entitlements, and the employment of lawyers first to obtain and then to protect entitlements – all of these things consume substantial social resources. (2) Intellectual-property rights sometimes impede cumulative innovations. Suppose Innovator #2 wishes to build upon the work of Innovator #1. The need to secure a license from Innovator #1 will, at a minimum, add to Innovator #2's costs. If, for some reason, Innovator #1 is unable or unwilling to grant the license, the work of Innovator #2 may be frustrated altogether. (3) By empowering innovators to charge consumers more than the marginal cost of replicating their innovations, intellectual-property rights have the unfortunate effect of pricing some consumers out of the markets for the goods produced with those innovations. The result is a loss of the consumer surplus that otherwise might have been reaped by those consumers. This effect is commonly depicted graphically as follows:

⁸ See 17 U.S.C. §106(1) & (2).

Figure 1: Economic Effects of Profit-Maximizing Pricing of an Intellectual-Property Right



The rational owner of an intellectual-property right in a product or process for which there are not close substitutes will use his market power to adjust the price for the product or process until the marginal revenue of supplying an additional unit equals the marginal cost of doing so (point E, corresponding to quantity F and price B), thereby enabling the owner to reap monopoly profits in the amount of figure BDEC. Consumers represented by line segment OF will continue to reap consumer surplus in the amount of figure ABD. But consumers represented by line segment FH, who would have been able to purchase the good or service had it been priced at marginal cost, will now be unable to do so. The result is a “deadweight loss” in the amount of figure DEG.⁹

Recognition of these drawbacks suggests that intellectual-property rights should not be created and extended casually. Instead, they should be established only in contexts in which their benefits (in terms of stimulating productivity) exceed their concomitant social costs. That basic insight has guided many scholars’ efforts to determine the optimal scope of intellectual-property rights. A classic study of this sort is William

⁹ Somewhat more precisely, the foregone consumer surplus will consist of figure DEG minus the consumer surplus reaped by those consumers when they use their money to purchase the next most attractive good or service. This refinement, however, in no way affects the analysis that follows.

Nordhaus' effort to determine the optimal duration of patent rights.¹⁰ Each increase in the duration or strength of patents, Nordhaus observed, stimulates an increase in inventive activity. The resultant gains to social welfare include the discounted present value of the consumer surplus and producer surplus associated with the distribution of the intellectual products whose creation is thereby induced. At the same time, however, social welfare is reduced by such things as larger administrative costs and larger deadweight losses associated with the higher prices of intellectual products that would have been created even in the absence of the enhanced incentive. Ideally, patent duration or strength should be increased up to the point where an additional extension would generate more social costs than benefits.¹¹ Other analyses in the same vein include Louis Kaplow's efforts to locate the optimal boundary between patent law (which permits and encourages the exercise of monopoly power) and antitrust law (which forbids it) – and my own effort to suggest how the fair-use doctrine in copyright law might be reshaped.¹²

B.

Many years ago, Harold Demsetz argued that the copyright and patent systems play the important roles of letting the potential producers of intellectual products know what consumers want and thus channeling productive efforts in directions most likely to enhance consumer welfare.¹³ In the past decade, a growing group of theorists has argued that recognition of this function justifies expanding the copyright and patent systems. In Paul Goldstein's words:

¹⁰ William D. Nordhaus, *Invention, Growth, and Welfare: A Theoretical Treatment of Technological Change* (Cambridge: M.I.T. Press, 1969).

¹¹ Among the lessons that Nordhaus derived from his analysis are that “commodities that have lower elasticity of demand have higher optimal [patent] lives” and that “patents for industries having more progressive (or easier) invention should have shorter lives.” *Ibid.*, p. 79. Many essays attempt to refine or apply the general approach developed by Nordhaus. See, for example, Pankaj Tandon, “Optimal Patents with Compulsory Licensing,” *Journal of Political Economy* 90 (1982): 470-86; Richard Gilbert and Carl Shapiro, “Optimal Patent Protection and Breadth,” *Rand Journal of Economics* 21 (1990): 106-12; Paul Klemperer, “How Broad Should the Scope of Patent Protection Be?,” *Rand Journal of Economics* 21 (1990): 113-30; and Frederic M. Scherer, *Industrial Market Structure and Economic Performance* (2d ed., Chicago: Rand McNally, 1980), pp. 439-58.

¹² See Louis Kaplow, “The Patent-Antitrust Intersection: A Reappraisal,” *Harvard Law Review* 97 (1984): 1813-92; William Fisher, “Reconstructing the Fair Use Doctrine,” *Harvard Law Review* 101 (1988): 1659.

¹³ See Harold Demsetz, “Information and Efficiency: Another Viewpoint,” *Journal of Law and Economics* 12 (1969): 1.

The logic of property rights dictates their extension into every corner in which people derive enjoyment and value from literary and artistic works. To stop short of these ends would deprive producers of the signals of consumer preference that trigger and direct their investments.¹⁴

Won't adoption of this strategy impede public dissemination of intellectual products? Not at all, say the proponents of this approach. Sales and licenses will ensure that goods get into the hands of people who want them and are able to pay for them. Only in the rare situations in which transaction costs would prevent such voluntary exchanges should intellectual-property owners be denied absolute control over the uses of their works – either through an outright privilege (such as the fair-use doctrine) or through a compulsory licensing system.¹⁵

Another group of theorists, however, point out that, if we expand our frame of reference, the recommendation set forth above proves problematic.¹⁶ In virtually no field of economic activity are innovators empowered to collect the full social value of their innovations. The elementary schoolteacher who develops a new technique for teaching mathematics, the civil-rights activist who discovers a way to reduce racial tension, the physicist who finds a way to integrate our understandings of gravity and quantum mechanics – all of these confer on society benefits that vastly exceed the innovators' incomes. Enlarging the entitlements of intellectual-property owners thus might refine the signals sent to the creators of different sorts of fiction, drugs, and software concerning consumers' preferences, but would lead to even more serious *over*investment in intellectual products as opposed to such things as education, community activism, and primary research. An optimal system thus would somehow have to take into account

¹⁴ See Paul Goldstein, *Copyright's Highway* (New York: Hill & Wang, 1994), pp. 178-79.

¹⁵ See Wendy J. Gordon, "An Inquiry into the Merits of Copyright: The Challenges of Consistency, Consent, and Encouragement Theory," *Stanford Law Review* 41 (1989): 1343, at 1439-49; Robert P. Merges, "Are You Making Fun of Me?: Notes on Market Failure and the Parody Defense in Copyright," *AIPLA Q.J.* 21 (1993): 305, at 306-07; Neil Netanel, "Copyright and a Democratic Civil Society," *Yale Law Journal* 106 (1996): 283, at 308-310. In this vein, Robert Merges has argued that lawmakers should not be quick to institute compulsory licensing systems. Private institutions such as collective rights management organizations are likely to be superior to any governmentally mandated regime -- and will often spring up spontaneously if lawmakers refuse to intervene. See "Contracting into Liability Rules: Intellectual Property Rights and Collective Rights Organizations," *California Law Review* 84 (1996): 1293.

¹⁶See Glynn Lunney, Jr., "Reexamining Copyright's Incentives-Access Paradigm," *Vanderbilt Law Review* 49 (1996): 483.

both the signaling power of strong intellectual-property rights and their tendency to distort the signals provided to creative persons of other sorts.

C.

The final set of complications identified by intellectual-property theorists is related to but distinguishable from the second. Intellectual-property rights can sometimes stimulate *too much* innovation. In other words, they can sometimes give rise to socially wasteful duplicative or uncoordinated inventive activity. The foundation for this approach was laid by a group of economists, led by Yoram Barzel, who over the last three decades have explored the ways in which competition among firms complicates the impact of the patent system upon inventive activity.¹⁷ This body of literature has sensitized legal theorists to three stages in the inventive process at which economic waste can occur. First, the pot of gold represented by a patent on a pioneering, commercially valuable invention may lure an inefficiently large number of persons and organizations into the race to be the first to reach the invention in question. Second, the race to develop a lucrative improvement on an existing technology may generate a similar scramble for similar reasons at the "secondary" level. Finally, firms may try to "invent around" technologies patented by their rivals – *i.e.*, to develop functionally equivalent but non-infringing technologies – efforts that, although rational from the standpoint of the individual firm, represent a waste of social resources. Heightened awareness of these risks has prompted legal scholars to search for possible reforms of intellectual property

¹⁷ The work of this group of economists is well summarized in Peter Menell, "Intellectual Property: General Theories," *Encyclopedia of Law & Economics* (forthcoming), at 7-8. Among the leading works are: Yoram Barzel, "Optimal Timing of Innovations," *Rev. Econ. & Stat.* 50 (1968): 348-55; Partha Dasgupta, "Patents, Priority and Imitation or, The Economics of Races and Waiting Games," *Economics Journal* 98 (1988): 66, at 74-78; Partha Dasgupta and Joseph Stiglitz, "Uncertainty, Industrial Structure and the Speed of R&D," *Bell Journal of Economics* 11 (1980); 1, at 12-13; Drew Fudenberg, Richard Gilbert, Joseph Stiglitz, and Jean Tirole, "Preemption, Leapfrogging, and Competition in Patent Races," *European Economic Review* 77 (1983): 176-83; Michael L. Katz & Carl Shapiro, "R & D Rivalry with Licensing or Imitation," *American Economic Review* 77 (1987): 402; Steven A. Lippman & Kevin F. McCardle, "Dropout Behavior in R&D Races with Learning," *Rand Journal of Economics* 18 (1987): 287; Glenn C. Loury, "Market Structure and Innovation," *Quarterly Journal of Economics* 93 (1979): 395; Frederic M. Scherer, "Research and Development Resource Allocation Under Rivalry," *Quarterly Journal of Economics* 81 (1967): 359, at 364-66; Pankaj Tandon, "Rivalry and the Excessive Allocation of Resources to Research," *Bell Journal of Economics* 14 (1983): 152; Brian D. Wright, "The Resource Allocation Problem in R & D," in *The Economics of R & D Policy* 41, 50 (George S. Tolley, James H. Hodge & James F. Oehmke eds., 1985).

law – or of related doctrines, such as antitrust law – that would mitigate the dissipation of resources at these various sites.¹⁸

Unfortunately, exactly what system of legal rules would achieve that effect is far from clear. Trouble arises from the fact that reducing social waste at one stage of the inventive process commonly increases it at another. Thus, for example, in the leading article in this subfield, Edmund Kitch highlighted the advantages of granting to the developer of a pioneering invention an expansive set of entitlements, thereby enabling him to coordinate research and development dedicated to improving the invention, thus reducing the dissipation of rents at the secondary level.¹⁹ However, as Robert Merges argues, granting generous patents on pioneering inventions will exacerbate rent dissipation at the primary level. An even greater – and more socially wasteful – number of persons or firms will now race to be the first to develop pioneering patents. In addition, as Merges and Richard Nelson point out, efforts through broad primary patent grants to mitigate rent dissipation at the secondary level may have serious economic side effects. Instead of enabling the original inventor to coordinate efficiently the exploitation of the technology, it may lead to “satisficing” behavior and an inefficiently narrow focus on improvements related to the primary inventor's principal line of business.²⁰ Efforts to identify an optimal balance of these various effects continue, but no solution is yet in sight.²¹

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¹⁸ See Kaplow, *supra* note 12; Edmund Kitch, “The Nature and Function of the Patent System,” *Journal of Law and Economics* 20 (1977): 265; idem, “Patents, Prospects, and Economic Surplus: A Reply,” *Journal of Law and Economics* 23 (1980): 205; Mark F. Grady & J. Alexander, “Patent Law and Rent Dissipation,” *Virginia Law Review* 78 (1992): 305; Robert Merges & Richard Nelson, “On the Complex Economics of Patent Scope,” *Columbia Law Review* 90 (1990): 839-916; Mark Lemley, “The Economics of Improvement in Intellectual Property Law,” *Texas Law Review* 75 (1997): 993-1084.

¹⁹ See Kitch, “The Nature and Function of the Patent System,” *supra* note 18. See also Suzanne Scotchmer, “Protecting Early Innovators: Should Second-Generation Products Be Patentable?,” *Rand Journal of Economics* 27 (1996): 322-31.

²⁰ Merges & Nelson, “Complex Economics of Patent Scope,” *supra* note 18.

²¹ See Donald G. McFetridge & Douglas A. Smith, “Patents, Prospects, and Economic Surplus: A Comment,” *Journal of Law and Economics* 23 (1980): 197; A. Samuel Oddi, “Un-Unified Economic Theories of Patents -- The Not-Quite-Holy Grail,” *Notre Dame Law Review* 71 (1996): 267, at 283; Donald L. Martin, “Reducing Anticipated Rewards from Innovation Through Patents: Or Less is More,” *Virginia Law Review* 78 (1992): 351, at 356; Robert P. Merges, “Rent Control in the Patent Districts: Observations on the Grady-Alexander Thesis,” *Virginia Law Review* 78 (1992): 359, at 376-77.

This is as far as the theoretical inquiry can take us. The body of literature summarized above helps us in two ways: It alerts us to the set of strategies that a government might employ in seeking to stimulate socially optimal levels of innovation, and it identifies several ways in which intellectual-property rights, in particular, might either contribute to or, in some instances, impede the pursuit of that objective. But it is incapable of identifying a single, optimal solution to the problem.²² To make any further progress, we must turn from the theoretical literature to the empirical and historical literature. What specific innovation-enhancing policies have succeeded – and failed – in specific technological contexts? The following section of the paper takes up that question. The Conclusion will then seek to derive from those case studies some tentative generalizations about appropriate governmental policies in emerging technological fields.

II.

Four fields of technology are examined below: pharmaceuticals; biotechnology; aviation; and computer software. These fields have been selected partly because of their economic importance and partly because they illustrate different dimensions of the relationship between law and innovation.

A.

We begin with the pharmaceutical industry because it has traditionally – and properly – been seen as the field in which the argument in favor of intellectual-property rights is the strongest. All of the empirical and historical studies of the drug business conclude that patent rights have been crucial in fostering high rates of innovation and progress. For example, Edwin Mansfield found that 60% of the pharmaceutical inventions made between 1981 and 1983 would not have been developed at all and 65% of those inventions would not have been introduced into commerce if patent protection had been unavailable. These effects were approximately twice as strong as the effects of patent protection in the chemical industry, and no other technological field was anywhere

²² See Robert M. Hurt & Robert M. Schuchman, "The Economic Rationale of Copyright," *American Economic Review* 56 (1966): 425-26; Jessica Litman, "The Public Domain," *Emory Law Journal* 34 (1990): 997; George L. Priest, "What Economists Can Tell Lawyers About Intellectual Property," *Research in Law and Economics*, Vol. 8 (John Palmer, ed., 1986), pp. 19, 21; Lloyd Weinreb, "Copyright for Functional

near so sensitive to patent protection.²³ A subsequent study by Richard Levin, Alvin Klevorick, Richard Nelson, and Sidney Winter similarly found that, whereas in most industries patent protection was regarded by managers as a less effective means of protecting the competitive advantages of new processes and products than alternative mechanisms such as secrecy, lead time, and sales or service efforts, the pharmaceutical industry was one of the few settings in which patent protection was rated highly.²⁴ The same paper and a similar study by Mansfield, Schwartz and Wagner suggested the reason for this finding: patent protection raised the “imitation costs” borne by competitors far more in the pharmaceutical industry than in any other technological field.²⁵

What aspects of the pharmaceutical industry give patent protection in this context such power? We cannot say with certainty, but David Schwartzman’s study of the industry seems to identify the principal factors: (1) very high research-and-development costs (amplified by the high costs of securing government approval before new drugs may be sold to the public); (2) a high degree of uncertainty concerning whether any particular line of research will prove fruitful; (3) the ease with which the contents of new drugs can be ascertained by competitors through lawful “reverse engineering”; and (4) the low costs of manufacturing drugs. In combination, these conditions make innovators very vulnerable to imitators and decrease the efficacy of the alternative means (such as trade secrets) of warding imitators off.²⁶

Expression," *Harvard Law Review* 111 (1998): 1149, at 1232-36; John Shepard Wiley, Jr., "Bonito Boats: Uninformed but Mandatory Innovation Policy," *Supreme Court Review* (1989), 283.

²³ Edwin Mansfield, "Patents and Innovation: An Empirical Study," *Management Science* 32 (1986): 173, at 175. Mansfield also found that, within the pharmaceutical industry, "the more R and D-intensive firms [tended to] regard patents as much more important than the less R and D-intensive firms." *Ibid.* & n. 8.

²⁴ See Richard Levin, Alvin Klevorick, Richard Nelson, and Sidney Winter, "Appropriating the Returns from Industrial Research and Development," *Brookings Papers on Economic Activity* 3 (1987): 783, at 795-97. A recent study by Wesley Cohen, Richard Nelson, and John Walsh came to similar but not identical conclusions. Once again, participants in the drug industry placed more weight on patents as devices for appropriating product innovations than did the participants in almost any other industry. However, even in the drug industry, "secrecy" was regarded as an even more effective method of appropriation. See "Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (Or Not)," NBER Working Paper 7552 (February 2000), Table 1, available at <http://www.nber.org/papers/w7552>.

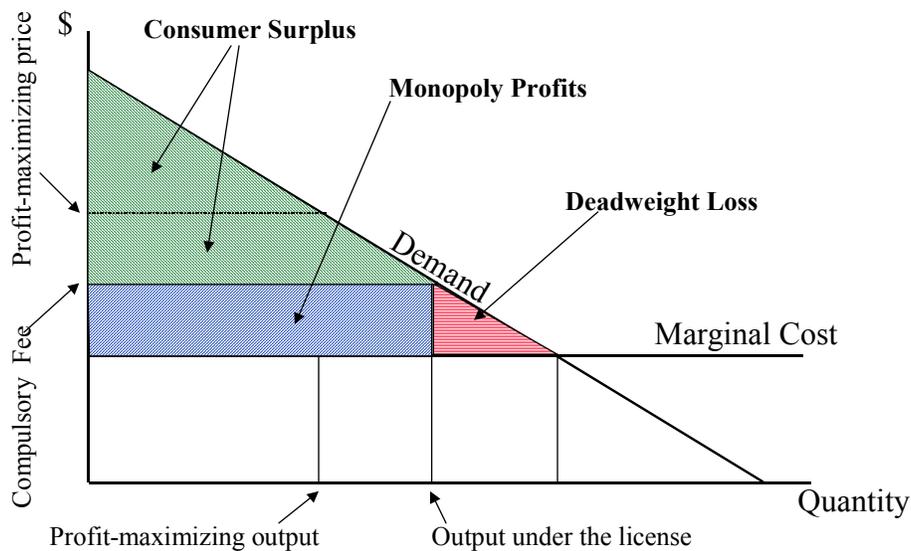
²⁵ See *ibid.*, at 811; Edwin Mansfield, Mark Schwartz, and Samuel Wagner, "Imitation Costs and Patents: An Empirical Study," *Economic Journal* 91 (1981): 907.

²⁶ See David Schwartzman, *Innovation in the Pharmaceutical Industry* (Baltimore: Johns Hopkins Univ. Press, 1976).

Unfortunately, the assignment to pharmaceutical firms of intellectual-property rights gives rise to an especially sharp version of one of the drawbacks discussed in the preceding section of this paper: The firms' exercise of the market power generated by those rights causes the prices of drugs to rise dramatically above the marginal cost of producing them, thereby placing them out of the financial reach of millions of people. Public or private health-insurance systems can, of course, offset this effect by enabling the cost of patented drugs to be passed along either to all taxpayers (in which case the exercise of intellectual-property rights begins to resemble governmental rewards for innovative activity) or to large populations of potential patients. However, when poor potential drug consumers live in countries lacking such insurance systems and when the drugs involved are potentially life-savings, the net result of monopoly pricing can be tragic – as has been demonstrated most recently by the systems for marketing patented AIDS drugs in Africa and Latin America.

Are there ways of administering a system of intellectual-property rights that simultaneously preserves its power to stimulate innovation in the pharmaceutical field and mitigates its adverse effect on the welfare of the poor? Yes, there are several – of which two deserve special mention. The first – and the one around which much contemporary controversy swirls – consists of compulsory licensing. A government might, on the one hand, award a patent to a pharmaceutical firm and, on the other hand, insist that the firm sell the drug at a specified price. The economic argument in favor of this strategy is illustrated below.

Figure 2: Economic Impact of a Compulsory License

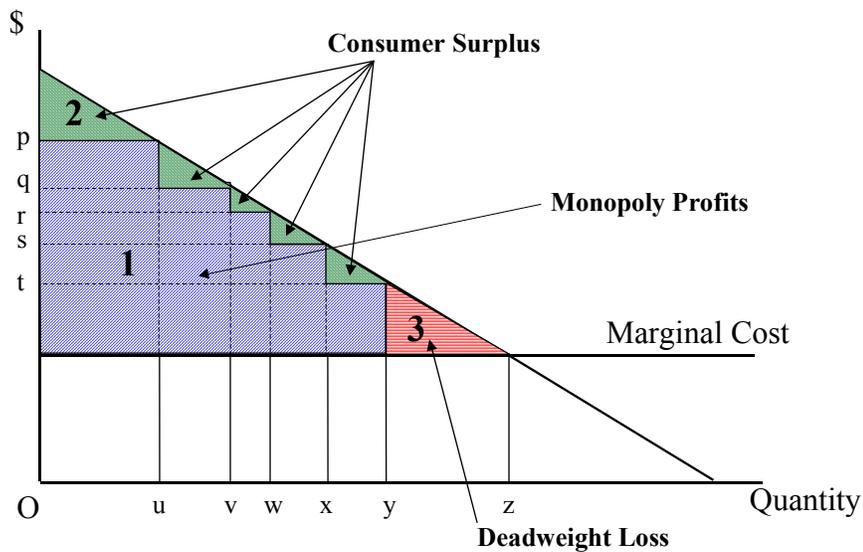


By compelling the firm to sell the drug at the specified “compulsory fee,” rather than at the “profit-maximizing price,” the imposition of a compulsory license both radically reduces welfare losses (compare the size of “Deadweight Loss” in Figure 2 with that in Figure 1, above) and increases the ratio of economic incentive to welfare losses (compare the ratio of “Monopoly Profits” to “Deadweight Loss” in Figure 2 with the comparable ratio in Figure 1), thus promoting economic efficiency. Compulsory licensing does, however, have two drawbacks of its own: First, administration of such a system is likely to incur substantial transaction costs. In extreme cases, those costs might exceed the economic advantages of employing this device. Second, compulsory licenses, by reducing the profits that firms can make (compare the size of “Monopoly Profits” in Figure 2 with that in Figure 1), may reduce the capacity of intellectual-property rights to stimulate innovation. The available empirical work provides little support for the latter effect.²⁷ However, the vigor with which the pharmaceutical companies resist compulsory licensing may give rise to some concern on this score.

²⁷ See F.M. Scherer, *The Economic Effects of Compulsory Patent Licensing* (New York: NYU School of Business Administration, 1977); Levin et al., *supra* note 24, at 804 (both concluding that compulsory licenses do not discourage spending on research and development and are not considered by managers significant limitations on the effectiveness of patents).

The second way in which intellectual-property rights in pharmaceutical products might be administered so as to preserve their power to stimulate innovation while mitigating their adverse effect on poor consumers is by adjusting the legal doctrines that affect the ability of patentees to engage in imperfect (or “third-degree”) price discrimination. The economic effects of price discrimination are exceedingly complex,²⁸ but at least a *prima facie* argument for encouraging this practice in the context of drug patents can be constructed as follows:

Figure 3: Economic Impact of Partial Price Discrimination



²⁸ Several articles on this issue have appeared in the past year or are currently in process. See, e.g., Julie Cohen, “Copyright and the Perfect Curve,” *Vanderbilt Law Review* 53 (2000): 1799; James Boyle, “Cruel, Mean, or Lavish? Economic Analysis, Price Discrimination and Digital Intellectual Property,” *Vanderbilt Law Review* 53 (2000): 2007. The author is currently at work on a reassessment of the economic and social effects of price discrimination in the marketing of intellectual property. The argument offered in the text is meant to suggest the importance of the topic and some of the relevant economic considerations, not to provide a definitive answer to the question of how much latitude should be afforded price discrimination.

Drug manufacturers may increase their profits substantially by dividing the pool of potential consumers into discrete subgroups (e.g., by region, age, or income bracket) and then charging the members of each subgroup what they are able and willing to spend. Thus, on the simplified assumptions embodied in Figure 3, a firm holding a patent on a drug for which there are not good therapeutic substitutes could charge the consumers represented by line 0-U price p, charge consumers U-V price q, charge consumers V-W price r, charge consumers W-X price s, and charge consumers X-Y price t. Compared to the profits the firm might make in the absence of price discrimination (see Figure 1), the profits reaped through this strategy are much larger. Plainly this benefits the firm, but it *may* also benefit society at large as well. Notice that the number of potential consumers deprived of access to the drug is much smaller under this scenario than was the case where the patentee charged a single price.²⁹ In addition, (as was the case with compulsory licensing), the ratio of the economic incentives to welfare losses increases sharply under these assumptions (compare the ratio of “Monopoly Profits” to “Deadweight Loss” in Figure 3 with the comparable ratio in Figure 1), thus potentially promoting economic efficiency. A comprehensive analysis of this issue would have to take into account many other factors as well, including the impact of pricing strategies of this sort on competition within the drug industry and the transaction costs incurred by firms that must establish and police the boundaries between sub-markets. But this technique at least creates the possibility that the social advantages of patent rights might be preserved while their concomitant social costs are reduced.

What are the implications of this analysis for the design of intellectual-property laws? It suggests that governments ought to consider revising the rules that currently affect opportunities for price discrimination – such as the legitimacy of nonmetered

²⁹ Cf. Neil Weinstock Netanel, “Asserting Copyright’s Democratic Principles in the Global Arena,” *Vanderbilt Law Review* 51 (1998): 217, at 325-27 (exploring the potential of price discrimination to increase the distribution of intellectual products to the residents of underdeveloped countries). The question whether pursuit of this strategy results in a diminution of total consumer surplus – i.e., whether the gains reaped by low-margin consumers exceed the losses sustained by high-margin consumers – is complex. Attempts to answer it include W. Kip Viscusi, *Economics of Regulation and Antitrust* 290-95 (2d ed. 1995); Michael Meurer, “Price Discrimination, Personal Use, and Piracy: Copyright Protection of Digital Works,” *Buffalo Law Review* 45 (1997): 845, at 897-98; William Fisher, “Property and Contract on the Internet,” *Chicago-Kent Law Review* 73 (1999): 1203, at 1239-40. The answer, though important, does not affect the simpler proposition set forth in the text

patent licenses, the enforceability of contractual limitations on the resale or reuse of patented products, and the rules governing “parallel imports” of patented drugs.

B.

One might expect that the biotechnology industry would behave much like the traditional pharmaceutical industry. Indeed, biotechnology can be seen as, at least in part, merely a new means by which pharmaceutical products are developed and produced. More generally, several of the circumstances that argue in favor of strong patent rights in the pharmaceutical industry – high research-and-development costs; uncertainty concerning whether particular lines of research will prove fruitful; relatively easy “reverse engineering”; and low manufacturing costs – may also be found in biotechnology. These factors have prompted the legislature and courts in the United States to look with favor upon biotechnology when reshaping or interpreting patent doctrines³⁰ and have led some commentators to advocate continued generous patent protection for innovations in this field.³¹

However, John Golden argues persuasively in a recent article that three aspects of the biotechnology industry as it has developed in the United States (where, since its genesis in the 1970s, it has been especially successful³²) differentiate it from the pharmaceutical industry and complicate the task of determining the appropriate kind and degree of intellectual-property protection in this area.³³ First, a remarkably high

³⁰ See, e.g., Rebecca S. Eisenberg, “Proprietary Rights and the Norms of Science in Biotechnology Research,” *Yale Law Journal* 97 (1987): 177, at 189; Anita Varma & David Abraham, “DNA Is Different: Legal Obviousness and the Balance Between Biotech Inventors and the Market,” *Harvard Journal of Law & Technology* 9 (1996): 53, at 56.

³¹ See, e.g., Kenneth J. Burchfiel, *Biotechnology and the Federal Circuit* (Washington, D.C.: Bureau of National Affairs, 1995); Lewis M. Branscomb & James H. Keller, “Towards a Research and Innovation Policy,” in *Investing in Innovation, Creating a Research and Innovation Policy That Works* (Cambridge, Mass.: MIT Press, 1998); Carrie F. Walter, “Beyond the Harvard Mouse: Current Patent Practice and the Necessity of Clear Guidelines in Biotechnology Patent Law,” *Indiana Law Journal* 73 (1998): 1025, at 1048.

³² For indications of the strength of the American biotechnology industry, see Lawrence M. Rausch, “International Patenting Trends in Biotechnology: Genetic Engineering,” *SRS Issue Brief* (National Science Foundation, Arlington, Va.), NSF 99-351 (June 18, 1999), available at <http://www.nsf.gov/sbe/srs/issuebrf/ib.htm>.

³³ Much of the following analysis is derived from John Golden, “Biotechnology, Technology Policy, And Patentability: Natural Products and Invention in the American System,” forthcoming in *Emory Law Journal* (2001).

percentage of the major innovations in biotechnology derive, not from research and development by private firms, but either from government research or from the work of university researchers whose activities, in turn, typically are funded by the federal government. The scale of governmental spending in this field is extraordinary; in the fiscal year 2000, the National Institutes of Health spent \$1.7 billion on basic biotechnology-related life-science research in its own laboratories, \$10.1 billion on individual life-science research grants (most of which went to university researchers), and \$1.6 billion on similar grants to university research centers.³⁴ One manifestation of the impact of that funding is that 71.6% of the citations in biotechnology patent applications are to research papers that were publicly funded and an additional 10.9% are to papers that were funded by both public and private monies.³⁵

Second, even in the private-sector biotechnology firms, the researchers who generate technological advances are motivated to a striking degree by what might be described as “public-sector values” rather than by the lure of large incomes. What prompts the members of this particular “inventor class” to devote much of their youth to arduous, largely uncompensated education and then prompts them to commit the rest of their lives to research? Not, it turns out, the hope of earning a great deal of money. Rather, the principal motivators are, first, an altruistic commitment to “the advancement and wide dissemination of scientific and technical knowledge” and, second, a less altruistic hunger for status and credit within the largely academic community of life scientists.³⁶

Third, biotechnology research tends to be highly cumulative. The development of new techniques or the sequencing of new genes reveals many possible additional advances, which in turn catalyze still others. The proliferation, strengthening, and enforcement of patents on early inventions thus raise the costs of subsequent inventions,

³⁴ See National Institutes of Health, *Press Briefing, Fiscal Year 2001 President's Budget*, available at <http://www4.od.nih.gov/ofm/budget/fy2001Pressbriefing.htm>.

³⁵ See G. Steven McMillan, Francis Narin & David L. Deeds, “An Analysis of the Critical Role of Public Science in Innovation: The Case of Biotechnology,” *Research Policy* 29 (2000): 1, at 5.

³⁶ Golden, *supra* note 33, at 49; Arti Rai, “Regulating Scientific Research: Intellectual Property Rights and the Norms of Science,” *Northwestern Law Review* 94 (1999): 77, at 88-94.

which commonly incorporate or require the use of the early advances.³⁷ Equally seriously, the highly decentralized, small-firm-dominated structure of the American biotechnology industry (often celebrated as one of the conditions that fosters rapid innovation³⁸) inhibits the development of patent licensing systems that would enable the “downstream” researchers to get on with their work. The resultant impediments to innovation (reinforced by an increasingly “proprietary” mood on the part of both universities and private firms) are causing growing anxiety among both members and observers of the biotechnology industry.³⁹

The convergence of these three factors casts doubt on the conventional view that strong patent protection is socially desirable in this field. Together, they suggest that the lure of large profits from generous patents for basic discoveries is not necessary to sustain a high level of innovation and that such patents often seriously interfere with research activities. Strengthening of intellectual-property rights also poses a risk of undermining the public-sector values that thus far have been the life-blood of the field.⁴⁰ Does this suggest that society would be better off if we abandoned the (controversial) doctrine that purified and isolated DNA sequences are patentable⁴¹ and withdrew patent protection from new products (if not new processes) in the field of biotechnology? Not necessarily. As Golden shows, patent protection in this field can and does facilitate innovation, not so much by “spurring” it in the conventional fashion, as by “enabling” it – specifically “by providing small biotechnology firms, which are the heart of the American biotechnology industry, with an intermediate ‘product’ – patents that they can use to attract investment.”

³⁷ See Michael A. Heller & Rebecca S. Eisenberg, “Can Patents Deter Innovation? The Anticommons in Biomedical Research,” *Science* 280 (1998): 698.

³⁸ For an ingenious argument concerning why small, entrepreneurial firms are more likely to generate breakthrough innovations than large corporations, see F.M. Scherer, “The Innovation Lottery,” in Rochelle Dreyfuss et al., *Expanding the Boundaries of Intellectual Property* (New York: Oxford Univ. Press, 2001), pp. 3, 20-21.

³⁹ See Walter W. Powell, “Networks of Learning in Biotechnology: Opportunities and Constraints Associated with Relational Contracting in a Knowledge-Intensive Field,” in Rochelle Dreyfuss et al., *supra* note 38, at 252, 264-66; Heller & Eisenberg, *supra* note 37.

⁴⁰ See Rai, *supra* note 36, at 108-115 (documenting the erosion that has already occurred).

⁴¹ See *Amgen, Inc. v. Chugai Pharmaceutical Co.*, 927 F.2d 1200, 1218 (Fed. Cir. 1991). This principle was recently reaffirmed by the Patent and Trademark Office. See Utility Examination Guidelines, 66 C.F.R. 1092, 1093 (Jan. 5, 2001).

But it does suggest that we should not be lavish in awarding biotechnology patents, especially in contexts in which they might impede cumulative research.

One manifestation of the latter guideline is that we ought not extend patent protection to isolated partial gene sequences, whose biological functions have not yet been determined. How, doctrinally, can this be achieved? In American patent law, this outcome can be reached most directly through strict enforcement of the requirement that inventions to be patentable must be “useful.”⁴² In the *Brenner* case, that doctrine was construed to forbid the patenting of chemical compounds whose only known use was to facilitate further research.⁴³ Very recently, the Patent and Trademark Office in the United States has sensibly decided to enforce the same principle in the context of gene sequences.⁴⁴ For the time being, the new patent examination guidelines may be sufficient to prevent excessive patent protection for biotechnological innovations. But, in the future, additional limitations on the extension of patents in this area may be advisable.

C.

In the aircraft industry, patents seem to have been much less important in stimulating innovation than they have been in the pharmaceutical field or than some commentators claim they could and should be in the biotechnology field. In 1971, Almarin Phillips found that innovators in this area had tended to rely primarily on lead time and learning-curve advantages, rather than patents, to profit from their advances.⁴⁵ The 1987 study by Levin, Klevorick, Nelson, and Winter of the values placed on patents by research-and-development executives in various industries reached a similar conclusion. Executives in the field of “aircraft and parts” regarded patents on both processes and patents as relatively ineffective ways of protecting the competitive

⁴² See Golden, *supra* note 33; Michael Heller, “The Boundaries of Private Property,” *Yale Law Journal* 108 (1999): 1163, at 1174-75.

⁴³ *Brenner v. Manson*, 383 U.S. 519 (1966).

⁴⁴ Utility Examination Guidelines, 66 Fed. Reg. 1092 (Jan. 5, 2001) (imposing on an applicant the burden of demonstrating utility unless it is “readily apparent” that the claimed invention has a “specific, substantial, and credible” utility). The application of this guideline to gene patent applications is considered in Elizabeth Weiswasser, “New PTO Guidelines to Affect Biotech Patents,” *National Law Journal*, February 1, 2001.

⁴⁵ Almarin Phillips, *Technology and Market Structure: A Study of the Aircraft Industry* (Lexington, Mass.: D.C. Heath, 1971).

advantages of technological advances.⁴⁶ This does not imply, of course, that firms in the industry have been reluctant to apply for or enforce patents. Patents are potential sources of profits. Thus we should not be surprised to find that the research-intensive aircraft industry has witnessed vigorous patenting activity.⁴⁷ In sum, aircraft patents are commonly issued but are not generally seen as primary ways of protecting technological advances. Under these circumstances, it seems likely that the patent system has impeded technological progress in the aircraft field more than it has stimulated it.

The history of the famous struggle within the industry over lateral stabilization technology is consistent with that conclusion. For many years, inventors had attempted without success to prevent an airplane from tipping uncontrollably from side to side when it encountered turbulence. Finally, the Wright brothers, relying on their observations of buzzards, solved the problem “by constructing a mechanism that warped the horizontal plane of an airplane’s wings at either side in opposite directions.”⁴⁸ The mechanism was a real breakthrough and made possible the Wright brothers’ famous flight in 1903. It is thus not surprising that they were able to patent the technology and that the federal courts subsequently interpreted that patent expansively.⁴⁹ Enforcement of the Wright patent, however, had troubling effects. Soon after the Wright brothers’ innovation, Glen Curtiss, a young designer working in conjunction with Alexander Graham Bell, devised an alternative method of stabilizing an airplane laterally, using ailerons or wing flaps. The superiority of this method quickly became apparent, and soon all aircraft used the Curtiss system – upon which Curtiss eventually received a patent of his own.⁵⁰ The Wright brothers, however, argued successfully that the Curtiss system infringed their own patent.⁵¹ A license agreement could, of course, have permitted all parties to take full advantage of both innovations. However, the rivalry between the two groups seems to

⁴⁶ Levin et al., *supra* note 24, at 797.

⁴⁷ See George Bittlingmayer, “Property Rights, Progress, and the Aircraft Patent Agreement,” *Journal of Law and Economics* 31 (1988): 227, at 238.

⁴⁸ Bittlingmayer, *supra* note 47, at 230-31.

⁴⁹ See Carl Zollmann, “Patent Rights in Aircraft,” *Marquette Law Review* 11 (1927): 216, at 218.

⁵⁰ Bittlingmayer, *supra* note 47, at 231.

⁵¹ See *Wright Co. v. Herring-Curtiss Co.*, 204 F. 597, 614 (W.D.N.Y. 1913), *aff’d* 211 F. 654 (2d Cir. 1914).

have prevented such a solution.⁵² The seriousness of the threat posed by this standoff to the progress of the industry as a whole became apparent when, as the First World War approached, many firms expressed reluctance to begin supplying airplanes to the United States military out of fear that they would be exposed to patent infringement suits.⁵³ Merges' and Nelson's assessment of this situation seems persuasive: "There is good reason to believe that the Wright patent significantly held back the pace of aircraft development in the United States by absorbing the energies and diverting the efforts of people like Curtiss."⁵⁴

What broke the impasse? Pressure from the government proved critical. The secretaries of the army and navy issued pleas for harmony, and Congress considered legislation that would have condemned the Wrights' patent. Under this cloud, the Wright enterprise relented and agreed to a patent licensing agreement similar to the one already in effect in the automobile industry. Under the terms of that agreement, each member firm of a new aircraft association granted to all other members permission to use its patented technology. Members paid the association \$200 for each airplane they produced. Approximately two thirds of that money went to the Wright enterprise while its patent lasted, then to the Curtiss enterprise while its patent lasted. After that point, fees dropped precipitously. Members of the association promised in the future to cross-license to other members all new patents on innovations in aircraft structure. Such licenses were to be royalty free unless a private board of arbitrators ruled that the invention in question was a genuine breakthrough, in which case the board could order the payment of royalties. By most accounts, this agreement worked well until 1972, when the Department of Justice, for reasons that remain contested, attacked it on antitrust grounds. While the agreement remained in force, the aircraft industry, though highly concentrated, remained extremely competitive, and technological progress was rapid.⁵⁵

What lessons can we derive from this story? First and most obviously, under conditions of the sort that characterized the aircraft industry, patents can do more harm

⁵² See Merges & Nelson, *supra* note 18, at 890.

⁵³ Bittlingmayer, *supra* note 47, at 231-32.

⁵⁴ Merges & Nelson, *supra* note 18, at 890-91.

than good. The only reason to hesitate before making such a sweeping judgment would seem to be Edmund Kitch's suggestion that a broad patent issued to a technological pioneer can be socially beneficial by empowering him or her to coordinate subsequent research and development in the field, thus reducing rent dissipation associated with the uncoordinated, rivalrous activity by secondary inventors.⁵⁶ However, as Merges and Nelson point out, the manner in which the Wright enterprise sought to enforce its pioneering patent on lateral stabilization technology casts considerable doubt upon the power of the Kitch thesis in the aircraft field – and, indeed, casts doubt upon its applicability in other contexts as well.⁵⁷

Second, if (as seems likely) a government is unwilling or unable to withdraw patent protection altogether from innovators in such a field,⁵⁸ it should consider encouraging the negotiation of a cross-licensing agreement among the members of the industry so as to reduce the impediments to technological progress. Cross-licensing agreements of course vary in the extent to which they can facilitate oligopolistic practices, and the government would be wise to administer and apply its antitrust laws so as to discourage kinds of agreements likely to produce cartel behavior.⁵⁹ But it ought not

⁵⁵ See Bittlingmayer, *supra* note 47, 232-48.

⁵⁶ See note 19, *supra*, and accompanying text.

⁵⁷ See Merges & Nelson, *supra* note 18, at 891.

⁵⁸ Such a radical solution, though arguably wise from an economic standpoint, would violate the *Agreement on Trade-Related Aspects of Intellectual Property Rights* – to which all member countries of the World Trade Organization are committed. See Article 27(1): “[P]atents shall be available for any inventions, whether products or processes, *in all fields of technology*, provided that they are new, involve an inventive step and are capable of industrial application. ... [P]atents shall be available and patent rights enjoyable without discrimination as to the place of invention, *the field of technology* and whether products are imported or locally produced.” (emphasis added)

⁵⁹ See John H. Barton, “Patents and Antitrust: A Rethinking in Light of Patent Breadth and Sequential Innovation,” *Antitrust Law Journal* 65 (1996): 449 (discussing the risk that cross-licenses among leading firms of fundamental patents will raise barriers to entry); Federal Trade Commission Staff, “Anticipating the 21st Century: Competition Policy in the New High-Tech, Global Marketplace” (May 1996), Volume I, Chapter 8, pp. 8-9 (available at: <http://www.ftc.gov/opp/global.htm>) (discussing the economic advantages and disadvantages of cross-licensing arrangements and patent pools); Steven Carlson, “Patent Pools and the Antitrust Dilemma,” *Yale Journal on Regulation* 16 (1999): 359, at 379-98 (same); Richard Gilbert & Carl Shapiro, “Antitrust Issues in the Licensing of Intellectual Property: The Nine No-No’s Meet the Nineties,” *Brookings Papers: Microeconomics* (1997): 283, at 325-28 (suggesting that patent pools are most likely to be anticompetitive when they involve competing [rather than complementary] patents, when they enable the pool to set royalty rates that must be paid by third parties, and when they are “prospective.”)

forbid patent licensing agreements altogether; on the contrary, in fields that resemble aircraft, the government should foment such agreements.⁶⁰

The third possible lesson draws on the recent article by Shavell and Ypersele, discussed in Part I, above.⁶¹ Those authors argue that economic efficiency would be enhanced if inventors could choose between patents and government-issued rewards for their inventions. One way in which such an optional regime could be implemented, they point out, would be for the government to leave the existing patent system in place but then to offer to purchase, at freely negotiated prices, extant patents. Technology sold to the government on this basis would then be released to competitors and to the general public for free. A situation of the sort exemplified by the early history of the aircraft industry – in which a broad, pioneering patent is wielded in a fashion that impedes the further development of the field – would seem an ideal situation in which to consider implementation of the Shavell/Ypersele proposal.

D.

The history in the United States of intellectual-property protection for computer software is complex, but broadly speaking the legal entitlements available to software programmers have been gradually increasing for 30 years. Early on, the creators of software programs could and did rely on a combination of secrecy and trade-secret law to shield their innovations from competitors. For example, by disclosing to the public only the object code embodying their creations and keeping the source code proprietary, software manufacturers could reduce considerably the vulnerability of their creations to replication. The law on this issue has not changed radically in many years, but gradual improvements in “decompilers” – which make it possible (lawfully) to convert object code into source code – is eroding in practice the effectiveness of this tactic.

⁶⁰ In a recent article, Robert Merges examines a wide variety of old and new patent pools, emphasizing their social advantages and arguing that they deserve lenient treatment under the antitrust laws. Although Merges assumes that such pools will ordinarily arise in the absence of governmental intervention, he recognizes in his conclusion the possibility that “the ‘visible hand’ of government” may occasionally be needed “to prod or even force parties into transactions.” Merges, “Institutions for Intellectual Property Transactions: The Case of Patent Pools,” in Dreyfuss et al, *supra* note 38, at 123-65.

⁶¹ See note 4, *supra*.

However, what the programmers have lost in terms of trade-secret protection, they have more than regained in the form of strengthened copyright and patent protection. The relevant copyright laws crystallized first. Adjustments to the copyright statute in 1980 made clear that software is copyrightable subject matter. Since then, the courts have invoked copyright law to forbid, not merely verbatim reproduction of software programs, but the creation of various kinds of structurally or functionally similar programs. Enforcement of these principles remains spotty in some countries, but in the United States enforcement efforts have been reasonably strong and effective.⁶²

Patent protection for software became available only later. Until 1981, the United States Supreme Court refused to treat software as patentable subject matter on the ground that mathematical algorithms no more deserve patents than laws of nature.⁶³ Between 1981 and 1998, the courts gradually retreated from this absolute position, first by permitting the patenting of software embedded in an “otherwise statutory process or apparatus,”⁶⁴ then by permitting the patenting of software combined with a general-purpose computer,⁶⁵ and finally by upholding patents issued to unadorned software programs.⁶⁶ This contorted doctrinal history slowed but by no means stopped the issuance of software patents by the Patent and Trademark Office. In the past few years, the steady stream has become a river. Currently, there are approximately 80,000 software patents in force in the United States, and the number is rising fast.⁶⁷

Has the gradual strengthening of intellectual-property rights for software fostered innovation in this industry? Perhaps. But three sets of circumstances, in combination, suggest that the law is now tighter than is necessary or appropriate. First, impressionistic evidence indicates that the pace of software innovation in the United States was very high

⁶² For a biased but nevertheless informative comparison of the varying degrees to which different jurisdictions enforce copyright protection for software, see <http://www.bsa.org/>.

⁶³ See *Gottschalk v. Benson*, 409 U.S. 63 (1972); *Parker v. Flook*, 437 U.S. 584 (1978).

⁶⁴ See, e.g., *Diamond v. Dehr*, 450 U.S. 175 (1981); *In re Abele*, 684 F.2d 902 (C.C.P.A. 1982).

⁶⁵ See *In re Alappat*, 33 F.3d 1526 (Fed. Cir. 1994) (en banc).

⁶⁶ See *State Street Bank & Trust Co. v. Signature Financial Group*, 149 F.3d 1368 (1998), cert. denied, 525 U.S. 1093 (1999).

⁶⁷ See Julie Cohen and Mark Lemley, “Patent Scope and Innovation in the Software Industry,” *California Law Review* 89 (2001): 1, at 11.

before the enhanced intellectual-property rights were established and has not increased since. Second, most programmers (in contrast to the executives of the software companies) believe that the new rules significantly hamper their work. Last but not least, several characteristics of the software industry exacerbate the dangers associated with excessive intellectual-property protection. The most obvious, perhaps, is the cumulative character of innovation in this field. Like biochemists, software programmers tend to rely heavily on the work of their predecessors. Indeed, it is customary for programmers, when confronting problems that have been addressed before, not merely to invoke and learn from the tried-and-true solutions developed by their predecessors, but to copy those solutions verbatim. The recent trends in copyright and patent law plainly threaten that socially efficient practice. A related circumstance – emphasized in a recent article by Julie Cohen and Mark Lemley – is that software programmers are much less likely than innovators in other fields to document their innovations in published articles. Keeping track of others’ entitlements, knowing when one is abridging entitlements and when one is not, is thus harder than would be true, for example, in biotechnology or electrical engineering.⁶⁸ Finally, network externalities – the social advantages that arise when all of the users of a particular type of technology adhere to the same standards and thus can share their work and move easily between machines and businesses – are especially strong in the context of computer software.⁶⁹ To the extent that strong intellectual-property rights inhibit the maintenance of common standards – e.g., by discouraging the creation of programs that are “interoperable” with other programs – such rights seem especially problematic.

These various considerations by no means suggest that intellectual-property protection should be withdrawn altogether from software. Protecting innovators against outright piracy – the unauthorized verbatim reproduction of entire programs – seems crucial to preserving the commercial market for software and thus the incentives for its creation. But that objective could be satisfied by a system of rules far narrower than the regime now in place in the United States.

⁶⁸ See *ibid.*, at 42.

⁶⁹ See Mark Lemley & David McGowan, “Legal Implications of Network Economic Effects,” *California Law Review* 86 (1998): 479.

What regime would be optimal? Some years ago, a team of scholars led by Pam Samuelson made a powerful argument for a “sui generis” system of legal protections for software that would take into account some of the characteristics summarized above.⁷⁰ A less revolutionary but still dramatic reform would withdraw patent protection for software, leaving only the milder copyright entitlements.⁷¹ A variation on the latter option would trim copyright protection for software even further, eliminating liability for so-called “nonliteral similarity” and leaving programmers (much like the owners of copyrights in sound recordings) protected only against the literal reproduction of the actual code in their creations.⁷²

None of the foregoing options, though certainly plausible from a policy standpoint, merits a great deal of attention, because none is within the zone of political practicability – certainly in the United States and probably in Europe. Assuming, for the moment, that both copyright and patent protection for software are here to stay, how might those systems be tuned so as to mitigate the ways in which they seem currently to be impeding rather than fostering technological innovation? The following suggestions (each developed in detail by other scholars) seem the most promising:

- The large social advantages achieved when programs created by different firms are “interoperable” strongly suggest that programmers must be free to copy software temporarily when necessary to achieve such interoperability. The large majority of courts in the United States have construed copyright law (typically through a generous application of the fair-use doctrine) to permit unauthorized copying

⁷⁰ See Pam Samuelson, Randall Davis, Mitchell Kapor, and Jerome Reichman, “A Manifesto Concerning the Legal Protection of Computer Programs,” *Columbia Law Review* 94 (1994): 2308.

⁷¹ But cf. A. Samuel Oddi, “An Uneasier Case for Copyright Than for Patent Protection of Computer Programs,” *Nebraska Law Review* 72 (1993): 351.

⁷² Cf. 17 U.S.C. 114(b): “The exclusive right of the owner of copyright in a sound recording under clause (1) of section 106 is limited to the right to duplicate the sound recording in the form of phonorecords or copies that directly or indirectly recapture the actual sounds fixed in the recording. The exclusive right of the owner of copyright in a sound recording under clause (2) of section 106 is limited to the right to prepare a derivative work in which the actual sounds fixed in the sound recording are rearranged, remixed, or otherwise altered in sequence or quality. The exclusive rights of the owner of copyright in a sound recording under clauses (1) and (2) of section 106 do not extend to the making or duplication of another sound recording that consists entirely of an independent fixation of other sounds, even though such sounds imitate or simulate those in the copyrighted sound recording.”

for this purpose.⁷³ However, the question of whether patent law will contain a similar privilege has not yet been resolved. As Cohen and Lemley have argued, patent law should be adjusted to parallel copyright law in this respect – either through an expansive reading of the “experimental use” exception to patent infringement or, if necessary, through a special amendment to the patent statute.⁷⁴

- Courts should be reluctant to find a violation of intellectual property rights when one software program resembles – but only imperfectly – another. In copyright law, this result can be achieved through a parsimonious application of the criteria developed in the *Altai* case for assessing claims of nonliteral similarity.⁷⁵ In patent law, it can be achieved through an equally sparing application of the “equivalents” doctrine.⁷⁶
- Replication of aesthetic or functional features of the “interface” that a software user employs to interact with a program should not give rise to liability in either copyright or patent law – because the contrary result would both raise barriers to entry into a field and threaten network externalities.⁷⁷
- A patent should not be awarded to a software program unless the applicant has revealed enough information to enable other programmers to replicate and build upon its innovative features. In the United States, the “enablement” and “best mode” requirements would seem to require this outcome, but the Court of Appeals for the

⁷³ See, e.g., *Sony Computer Entertainment, Inc. v. Connectix Corp.*, 203 F.3d 596 (9th Cir. 2000); *Sega Enters. Ltd. v. Accolade, Inc.*, 977 F.2d 1510 (9th Cir. 1992).

⁷⁴ See Cohen & Lemley, *supra* note 67, at 29-37.

⁷⁵ See *Computer Associates International v. Altai, Inc.*, 982 F.2d 693 (2d Cir. 1992). The *Altai* test itself is substantially less favorable to plaintiffs than the tests that preceded it. See, e.g., *Whelan Associates v. Jaslow Dental Laboratory*, 797 F.2d 1222 (3d Cir. 1986), cert. denied, 479 U.S. 1031 (1987). However, courts purporting to apply the *Altai* doctrine have varied dramatically in their interpretations of it. Against the backdrop of the policy issues discussed in this paper, some of those interpretations seem overly generous. See, e.g., *Gates Rubber Co. v. Bando Chemical Industries*, 9 F.3d 823 (10th Cir. 1993); *Kepner-Tregoe, Inc. v. Leadership Software, Inc.*, 12 F.3d 527 (5th Cir.), cert. denied, 115 S.Ct. 82 (1994); *Softel, Inc. v. Dragon Medical and Scientific Communications*, 118 F.3d 955 (2d Cir. 1997).

⁷⁶ See Cohen and Lemley, *supra* note 67, at 50-56.

⁷⁷ The question of whether menu hierarchies (functional aspects of user interfaces) are shielded by copyright law has not been definitively resolved in the United States. One Court of Appeals ruled that the answer was no, see *Lotus Development Corp. v. Borland International*, 49 F.3d 807 (1st Cir. 1995), but the Supreme Court divided equally concerning the proper outcome of the case, 116 S.Ct. 804 (1996), and other circuit courts have suggested that they might rule to the contrary. It is well recognized that the aesthetic features of user interfaces are protected by copyright, see, e.g., *Stern Electronics v. Kaufman*, 669 F.2d 852 (2d Cir. 1982), but the scope of that protection remains uncertain, see, e.g., *Apple Computer v. Microsoft Corp.*, 35 F.3d 1435 (9th Cir. 1994).

Federal Circuit has been inexplicably lax in its interpretation of those requirements.⁷⁸ That position should be reversed.

- In general, courts should stand ready to deploy the affirmative defenses of copyright misuse and patent misuse to prevent the developer of a software program that enjoys market power in one context (e.g., word processing or operating systems) from leveraging that power into control of another field (e.g., spreadsheet programs or browsers).

Conclusion

It is dangerous to try to derive general principles concerning the relationship between intellectual property and technological innovation from the particularities of case studies such as these. The distillation process inevitably forfeits both nuance and an appreciation of how various factors interact in specific technological contexts. But the effort nevertheless seems worthwhile, at least for the purpose of identifying some hypotheses that might be tested in other contexts. Here, then, are a few tentative generalizations suggested by the histories of the pharmaceutical, biotechnology, aviation, and software industries:

(1) Intellectual property rights are most likely to foster innovation when the following conditions converge in a particular industry: (a) high research-and-development costs; (b) a high degree of uncertainty concerning whether specific lines of research will prove fruitful; (c) the content of technological advances can be ascertained easily by competitors through “reverse engineering”; and (d) technological advances can be mimicked by competitors rapidly and inexpensively.⁷⁹

(2) The likelihood that intellectual-property rights will impede more than stimulate innovation increases as more and more of the following factors obtain in a

⁷⁸ See Lawrence Graham & Richard Zerbe, “Economically Efficient Treatment of Computer Software: Reverse Engineering, Protection, and Disclosure,” *Rutgers Computer and Technology Law Journal* 22 (1996): 61, at 96-97.

⁷⁹ The field of fashion design has long operated well in the absence of intellectual-property rights. Recently, however, improvements in the techniques for “reverse engineering” dress designs (factor (c)) and in automated fabrication (factor (d)) have strengthened the argument that an intellectual-property system should be instituted in this area. See Courtney Haas, “The Fashion Design Right: Folding Fashion Works into the U.S. IP Regime” (unpublished paper, April 6, 2001).

particular field: (a) trade-secret protection or lead-time advantages reduce the ability of competitors to take advantage of technological advances; (b) innovation in the field tends to be highly cumulative; (c) researchers in the field are motivated primarily by nonmonetary incentives; (d) the field is characterized by strong network externalities. The last three of these circumstances were all present during the development of the technical infrastructure of the Internet; it is thus not surprising that that development proceeded rapidly and effectively with little reliance upon intellectual-property systems.

(3) The following techniques may be employed to mitigate the economic side-effects of intellectual-property systems: (a) compulsory licenses; (b) facilitation of price discrimination; (c) strict enforcement of the “utility” requirement; (d) encouragement of appropriate cross-licensing agreements (provided that cartel behavior can be simultaneously discouraged); (e) narrow interpretations of “similarity”; (f) strict enforcement of “enablement” and “best-mode” requirements; and (g) the affirmative defenses of patent and copyright misuse.

(4) In contexts in which reliance upon these mitigating devices is not feasible, the following alternative ways of solving the public-goods problem may be superior to intellectual-property rights as ways of stimulating innovation: government research; government funding for private research; or *post-hoc* government rewards for private technological advances.