Chapter 6

Economics, Intellectual Property, and Software

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Introduction

Unfortunately, economists do not yet have a final word--or words—for us concerning the optimal intellectual property system for computer software. The topic of intellectual property applied to software has attracted increasing attention over the last decade, but the literature on the economics of software is still evolving, as is the broader economic literature on intellectual property and innovation.[1] Economists' efforts to understand these issues are made all the more difficult by the rapid changes in software technologies and markets. The discussion in this chapter, therefore, is only a 'snapshot' at this time, rather than an exposition of economists' ''solution' to the problem of how best to balance private incentives and social benefits in a rapidly moving area of technology. The following sections offer a perspective on the development of this literature and of economists' understanding of innovation and technological change.

In the ' 'U.S. intellectual property system, ' copyright, patent, and trademark are administered under Federal jurisdiction, as is protection for the topography of semiconductor chips. Laws concerning trade secrets and the misappropriation of confidential business information, trademarks not federally registered, and certain limited kinds of 'unfair competition' are under State jurisdiction.[2] The economics literature on intellectual property concentrates on Federal grants of patent and copyright. *In large part, this focus stems from the nature of patent and copyright: these exclusive rights (for limited periods of time) have been designed within a framework involving an economic tradeoff between private incentives and social benefits.*[3] *The* laws governing trade secrets do not incorporate this kind of explicit tradeoff.[4] Therefore, patent and copyright offer more established economic bases for theoretical and empirical analyses of markets for intellectual property. The resulting focus in the literature is reflected in the following discussion,[5] which spotlights some of the issues on intellectual property and innovation that economists have explored, including:

- the economic rationale for granting intellectual property rights-linkages between these rights and economic benefits to society as a whole;
- the balance between the benefits and costs accruing to intellectual property holders and to the public at large;
- factors affecting this balance and the socially "optimal' degree of protection;
- interindustry differences in the efficacy of patent protection;
- implications of dynamic models with cumulative innovation;
- choices in "optimal" patent design (term, breadth); and
- network externalities and compatibility.

[1] *OTA note:* Unless otherwise specified, OTA uses ''innovation' and ''innovative activity' in this chapter to refer to research and development (R&D) and other creative processes producing scientific and technological advances, whether the form of these advances would legally be considered copyrightable, patentable, or neither. Precisely speaking, ' 'innovation' is the technological *implementation* of a new idea, method, or device discovered by the process of ' 'invention. " The economics literature on R&D, intellectual property, and technological progress has focused mainly on patents—computer software is one of the few copyrightable works where ''authorship' directly con.. titutes technological progress—and has tended to use the terms ''imovation' and ''invention' synonymously. In reviewing the economics literature on this topic, OTA uses the authors' terminology.

[2] See Stanley M. Besen and Leo J. Raskind, ' 'An Introduction to the Law and Economics of Intellectual Property, '' *Journal ofEconomic Perspectives*, vol. 5, No. 1, winter 1991, pp. 3-27. Besen and Raskind review the basic economics of intellectual property and look at each of the modes in some detail.

[3] Private incentives are expected t. arise from the right holder's limited monopoly powers; social benefits are expected to include additional benefits to society from the induced disclosure and/or dissemination of innovations and technological advances.
For discussions of this balancing between private incentives and social benefits in the ''intellectual property bargain,'' see U.S. Congress, Office of Technology Assessment, *Intellectual Property Rights in an Age of Electronics and Information*, OTA-CIT-302 (Melbourne, FL: Kreiger Publishing CO., April 1986). See also Paul Goldstein, *Copyright—Principles, Law and Practice* (Boston, MA: Little, Brown and Co., 1989), secs. 1.1 and 1.2.

[4] *See* Besen and Raskind, op. cit., footnote 2, p. 23.
The rightful possessor of a trade secret does not have an exclusive right to usc the secret information, and the law only provides for legal remedies when the secret is lost through breach of contract or ''improper' means of discovery (e.g., industrial espionage). A trade secret may be maintained indefinitely. See ch. 2 and the section on trade secrets below; see also David Friedman et al., ''Some Economics of Trade Secret Law, ' *Journal of Economic Perspectives*, vol. 5, No. 1, winter 1991, pp. 61-72.

[5] This OTA report does not deal with trademark issues except as they relate to counterfeiting (see section on piracy in ch. 3).

Kenneth Arrow's seminal 1962 paper examined resource allocation problems in markets for information and invention and the obstacles to efficient functioning that information markets face.[6] He concluded that in a free-enterprise economy, there will be underinvestment in invention and research and underutilization of the resulting information:

> To sum up, we expect a free enterprise economy to underinvest in invention and research (as compared with an ideal) because it is risky, because the product can be appropriated only to a limited extent, and because of increasing returns in use. This underinvestment will be greater for more basic research. Further, to the extent that a firm succeeds in engrossing the economic value of its inventive activity, there will be an underutilization of that information as compared with an ideal allocation.[7]

The bulk of economic analysis on linkages among technological progress, economic welfare, and intellectual property has dealt with the patent system, rather than copyright-software is remarkable in being a technology for which copyright is so crucial. However, there is also a well-developed literature dealing with economic welfare, copyright, and consumer copying of journal articles, music, software, etc. (see the final section on home copying below). Moreover, many of the arguments concerning patents and duplication of innovations can be applied to software copyright, especially to issues like copyright protection of interfaces and the appropriate breadth of copyright protection.

As noted previously, this is an evolving literature. Sometimes, the analyses discussed in the following sections will differ in conclusions or policy implications. In particular, some of the economic research done since the National Commission on New Technological Uses of Copyrighted Works (CONTU) suggests policy implications that differ from those of earlier work in the 1950s, 1960s and early 1970s.[8] These differences result because the economic models depict different industry conditions, differ-

"One of the hallmarks of a competitive industry is the ease with which entrepreneurs may enter into competition with firms already doing business. The absence of significant barriers to entering the program-writing market is striking. There are several hundred independent firms whose stock in trade is computer programs. New software firms may be formed with few people and little money; entry into the market has thus far been fairly easy. None of the evidence received by the Commission suggests that affording copyright to programs would in any way permit program authors to monopolize the market for their products. Nor is there any indication that any firm is even remotely close to dominating the programming industry."

Final Report of the National Commission on New Technological Uses of Copyrighted Works (CONTU), **July 31, 1978, p. 23.**

"It seems to take courage even to register doubts about the net benefits oft he patent system. Some of the faithful, ardent believers in the patent system in its present form as an inherently moral institution, as a necessary component of private property, as an integral part of a free-enterprise economy, and as an indispensable spur to economic progress, have been quick to bear down on unbelievers with invectives and innuendoes. Perhaps this sort of pressure has something to do with the fact that agnostics on t he econom ics of patents often preamble their apprehensions about the consequences of patent protection in our time with affirmations of faith in the achievements of the past."

Fritz Machlup, An *Economic Review of the Patent System,* **Study of the Subcommittee on Patents, Trademarks, and Copyrights of the Committee on the Judiciary, U.S. Senate, Study No. 15 Pursuant to S. Res. 236, 85th Congress, 2d Sess. (Washington, DC: U.S. Government Printing Office, 1958), p. 43.**

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6 Kenneth J. Arrow, ''~onomic Welfare and the Allocation of Resources for Invention " in National Bureau of Economic Research, *The* Rate *and Direction of Inventive Activity: Economic and Social Factors* (Princeton, NJ: Princeton University Press, 1962), pp. 609-624.

Because information is intangible, even with legal protections, sellers cannot fully appropriate its value. On the demand side, potential buyers find it difficult to value information correctly, unless they have already acquired it. (Ibid., p. 615.)

7 Arrow, op. cit., footnote 6, p. 619.

In his analysis of incentives to invent in both monopolistic and competitive markets, Arrow found that although the incentive to invent was greater under competitive conditions, even then it was less than optimal, especially for major inventions (ibid., pp. 619 and 622). Arrow concluded that, while a preinvention monopoly might increase appropriability, the advantages of this additionat incentive would have to be "offset against the monopolist's disincentive created by his preinvention monopoly profits" (ibid., p. 622). Therefore, he concluded, government subsidies or other nonprofit financing for research and invention will be needed to compensate for the underallocation of resources to these activities (ibid., pp. 623-624).

8 As described by Sidney Winter, the pendulum of opinion on the "optimal' term of protection (e.g., whether increasing or decreasing the term of patent protection would be more socially desirable) has swung back and forth over the years. For his discussion of changes in economic thinking about the term and strength of protection see Sidney G. Winter, "Patents in Complex Contexts: Incentives and Effectiveness, " in Vivian Weil and John W. Snapper (eds.), *Owning Scientific and Technical Information (New* Brunswick NJ: Rutgers University Press, 1989), pp. 41-43.

For another discussion of the economics literature on innovation, see Robert P. Merges, "Commercial Success and Patent Standards: Economic Perspectives on Innovation," *California Law Review, vol. 76,* pp. 803-876, 1988.

ent types of innovation, and different timeframes. Much of the earlier economic work on intellectual property (mainly patents) focused on cost-saving *process* innovations, while later work looked at *product* innovations. Until after the mid- 1970s, most analyses of (socially) optimaI patent design focused on *patent term* and assumed static (one-shot) models of innovation. The more recent work focuses on *breadth of protection,* as well as term; dynamic models of innovation include the possibilities of multiple inventors,[9] cumulative innovation, and network externalities. The more recent work, using dynamic models for innovation, supports shorter, rather than longer, terms of protection.[10]

Public Goods and the Underlying Rationale for Granting Rights

In economic terms, a "public good" is one that has the property of *nonexclusivity:* once the good has been produced, it is impossible (or prohibitively costly) to exclude any individual from benefiting from it, whether or not he or she pays.[11] Indeed, individuals have an incentive not to pay for the good, or to undervalue it, in hopes of getting access as ''free riders.' The inability to exclude free riders distorts market signals and is thought to result in inefficient allocation of resources to nonexclusive goods and underproduction of them, relative to socially optimal quantities.

Public support is provided for some activities in order to overcome this imperfection in the market. Thus, some public goods—like national defense—are produced publicly by government and paid for by collective taxation. Some goods that are produced *privately also* face the problem of (at least partial) nonexclusivity. For these also, ordinary market forces may not produce the most desirable social outcomes.[12] Goods that have the property of nonexclusivity will tend to be produced in insufficient quantity or variety because producers are unable to fully benefit from investments in creating them.[13]

Establishment of a system of defined "intellectual property rights" can help alleviate this difficulty.[14] The Framers of the U.S. Constitution dealt with this market imperfection by giving Congress the power to grant copyrights and patents:

> The Congress shall have Power. . .To promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries. (U.S. Constitution, art. I, sec. 8, cl. 8.)

In granting a limited monopoly through copyright or patent, government attempts to compensate for distortions arising from nonexclusivity. According to this rationale, without the counterbalancing grants of monopoly power bestowed through copyright and patent, the inability of authors and inventors to appropriate economic returns from their labors would result in the underproduction of new works and inventions.

Using government grants of exclusive rights to produce countervailing distortions is not the only means to improve the efficiency of intellectual property markets; indeed, using a balanced set of public and private measures, rather than relying on expanded or strengthened intellectual property rights alone, may be desirable: [15]

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[9] In multiple-inventor ''patent races,' the rate of R&D spending affects the probability of invention.

[10] See Winter, op. cit., footnote 8, and below.

[11] For a discussion of public goods, see John Eatwell et al. (eds.), *The* New *Palgrave: A Dictionary of Economics* (The Stockton Press, NY: 1987), pp. *1061-1066.*

[12] This happens both because *nonpaying* individuals can gain access as free riders and because the information at the heart of the intellectual property can be ''consumed' without supply being exhausted. In contrast to markets for houses or antiques, consumers don't have to bid to exclude each other in order to use information.

[13] The National Commission on New Uses of Copyrighted Works (CONTU) recognized that the information comprising software innovation in computer programs 'is a prime example of a public good' (Peter Menell, ''An Analysis of the Scope of Copyright Protection for Application Programs,' *Stanford Law Review*, vol. 41, No. 5, May 1989, pp. 1045-1104, citing pp. 9-12 of the CONTU report on p. 1059).

[14] Inappropriability tends t. result in underallocation of resources to the production of these goods. Legally defined ''rights can alleviate the problem of inappropriability. See J.A. Schumpeter, *Capitalism, Socialism, and Democracy (New* York, NY: Harper, 1950); and R.H. Cease, ''The Problem of Social Cost,'' *Journal of Law and Economics,* vol. 3, No. 1, October 1960, pp. 1-44.

[15] See Peter S. Menell, ''Tailoring Legal Protection for Computer Software,'' *Stanford Law Review,* vol. 39, No. 6, July 1987, pp. 1329-1372.
In this article, Menell concludes that copyright protection for computer software does promote some types of innovation by prohibiting piracy, but with some diminution of benefits from increased diffusion of innovations, cumulative innovation and network externalities. Menell suggests a new congressional commission to study software protections. He also suggests that Congress should consider tailoring special protections for software to avoid overextending protection under copyright, and that protection be tailored differently for operating systems and application programs.

- The introduction of monopoly rights[16] can have adverse effects on the market in question. Economic theory holds that a monopolistic producer will tend to produce less of a good and charge a higher price, relative to competitive levels.[17] Moreover, the prospect of monopoly rights can create excessive incentives for certain classes of innovative activity, diverting resources from more socially beneficial ones.
- The monopoly rights can produce unintended, '' spillover' effects in other markets (e.g., transfer market power[18] from the software market to the hardware market or vice-versa).
- Establishing and administering intellectual property systems impose costs on the private and public sectors (e.g., costs to secure rights, litigation and/or negotiation costs, costs to ''invent around' or otherwise avoid infringing others' rights).

Therefore, as Peter Menell has noted, in assessing the need for new (or stronger) intellectual property protections:

> [I]t is important to assess the extent to which other forces-both market and non market-tend to offset the adverse effects of the public goods problem.[19]

These ''other" forces can include leadtime advantages from being first to introduce a product, licensing and service agreements, anticopying technologies, secrecy, government policies concerning antitrust and standards, research support, etc.[20] (For how and why some of these forces may have changed since CONTU, see box 6-A.)

Intellectual Property Systems and Net Social Benefits

The linkage between intellectual property rights and economic benefits to society as a whole has traditionally followed this logic: intellectual property rights increase innovators' ability to obtain returns from their intellectual labors; the resulting potential for increased private gains to innovators stimulates additional innovation; and, *because of increased innovation,* additional benefits accrue to society as a whole.[21] In *Mazer v. Stein, the* U.S. Supreme Court stated this rationale as follows:

> The economic philosophy behind the clause empowering the Congress to grant patents and copyrights is the conviction that encouragement of individual efforts by personal gain is the best way to advance public welfare through the talents of authors and inventors in Science and the useful Arts.[22]

The U.S. system of patents and copyrights is intended to strike a balance between the rights of intellectual property holders and the public at large. It is important to recognize that systems of legal protections for intellectual property impose costs on a society, as well as benefits. These costs include the costs of the additional innovation resulting from the intellectual property incentive, plus administrative

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16 *OTA note:* In this report, ''monopoly' is used in the economic sense and should *not* be taken as synonymous with illegal monopolization of a market or markets. For discussion, see F.M. Scherer, *Industrial Market Structure and Economic Performance,* 2d Ed. (Chicago, IL: Rand McNally College Publishing Co., 1980), pp. 527-594. As Scherer notes, "Congress [chose] the word 'monopolize' to describe what it condemned, and not some more conventional phrase such as 'obtain ox possess monopoly power' '' (ibid., p. 527),

17 See Scherer (1980), op. cit., footnote 16, pp. *14-20;* and Walter Nicholson, *Intermediate Microeconomics and Its Application, 2d* ed. @retie, IL: The Dryden Press, 1979), ch. 2 ("Pricing in Monopoly Markets), pp. 305-354.

''Monopoly rents' are the long-term economic profits resulting from prices that exceed average total cost: "These profits can be regarded as a return to that factor that forms the basis of the monopoly (a patent, a favorable location, a dynamic entrepreneur), hence another possible owner might be willing to pay that amount in rent for the right to the monopoly" (Nicholson, ibid., p. 309).

18 For a theoretical analysis of leveraging market power, see Michael D. Whinston, '' Tying, Foreclosure, and Exclusion, ' *The American Economic Review*, vol. 80, *No, 4,* September 1990, pp. 837-859.

For a discussion of market power and the practice of 'bundling' software and support with computer hardware, see Franklin M. Fisher et al., *Folded, Spindled and Mutilated: Economic Analysis and U S. vs. IBM* (Cambridge, MA: The MIT Press, 1983), pp. 204-215.

19 Menell (1987), op. cit., footnote 15, p. 1339.

20 Ibid., pp. 1339-1345.

21 For an excellent, comprehensive review of the development and functioning of the patent system, including historical perspectives on institutional issues and economic opinion on the social advantages and disadvantages of patent monopolies, see Fritz Machlup, *An Economic Review of the Patent System,* Study of the Subcommittee on Patents, Trademarks, and Copyrights of the Committee on the Judiciary, U.S. Senate, Study No. 15 Pursuant to S. Res. 236, 85th Congress, 2nd Sess. (Washington DC: U.S. Government Printing Office, 1958). Ch. IV reviews economic theory on patents from the mid- 18th to mid-20th centuries.

22 *Mazer* v. *Stein,* 347 U.S. **201,219** (1954).

and transaction costs[23] and foregone benefits to society from other innovations that would have taken place, without such protection.[24] Strengthening" the system or expanding its scope can increase these costs, and also increase economic losses to society from monopolistic exploitation of innovations:

> From the perspective of the public interest, the optimal system for protecting intellectual work equates the marginal benefit of enhancing the scope of intellectual work protection with the marginal cost of greater protection. . .That is, it equates the benefits of the availability of more and better products with research costs, losses due to monopolistic exploitation, administrative costs, and inhibiting effects on inventive activity. [n]

Nevertheless, much discussion about the U.S. intellectual property system is based on the assumption that, from an economic perspective, "better" or ‘‘stronger’ intellectual property protection is unequivocally ‘good. ’ This is based on the presumption that ‘ ‘stronger’ rights increase private incentives for innovation, producing additional technological progress and increased benefits to society overall.[26] But this is not necessarily the case.

"An economic evaluation of the patent system as a whole implies an analysis of the differences between its existence and nonexistence-perhaps a hopeless task,"

Fritz Machlup, An *Economic Review of the Patent System,* **Study of the Subcommittee on Patents, Trademarks, and Copyrights of the Committee on the Judicary, U.S. Senate, Study No. 15 Pursuant to S. Res. 236, 85th Congress, 2d Sess. (Washington, DC: U.S. Government Printing Office, 1958), p. 76.**

‘The analysis of the ‘increment of invention’ attributable tot he operation of t he patent system, or to certain changes in the patent system, can only be highly speculative, because no experimental tests can be devised to isolate the effects of patent protection from all other changes that are going on in the economy."

Fritz Machlup, *An Economic Review of the Patent System,* **Study of the Subcommittee on Patents, Trademarks, and Copyrights of the Committee on the Judiciary, U.S. Senate, Study No. 15 Pursuant to S. Res. 236, 85th Congress, 2d Sess. (Washington, DC: U.S. Government Printing Office, 1958), p. 62.**

‘The point is that *inventive* activity must precede the patent, whereas *innovating* activity may follow it. But the justification of the patent system as an incentive for innovating enterprise and for entrepreneurial investment would call for different supporting arguments than the justification as an incentive for invention. . .Moreover, there would be the additional question whether the promotion of innovating enterprise and of entrepreneurial investment can be held to be subsumed in the promotion of ‘science and t he useful arts’ which the Constitution *of* the United States stipulated as the sole objective of patent legislation."

Fritz Machlup, An *Economic Review of the Patent System,* Study of the Subcommittee on Patents, Trademarks, and Copyrights of the Committee on the Judiciary, U.S. Senate, Study No. 15 Pursuant to S. Res. 236, 85th Congress, 2d Sess. (Washington, DC: U.S. Government Printing Office, 1958), p. 56.

"Strength" of Protection and Social Benefits

In his recent review of theoretical issues and empirical findings regarding the patent system, Sidney Winter explains why there is now no general theoretical presumption in economics that the consequences of "stronger’ protections are favorable for society as a whole.[27] According to Winter, this contrasts with earlier thinking, when economists

23 Sometimes these transaction costs can be reduced by collective administration of licensing. In copyright markets for music and literary material, where the transaction costs of licensing are large compared to the value of the work to be licensed, collectives have been established. For example, the American Society of Composers, Authors, and Publishers (ASCAP) and Broadcast Music Inc. (BMI) collect and distribute performing rights royalties for composers, songwriters, lyricists, and music publishers; and the Copyright Clearance Center (CCC) collects and distributes photocopying royalties for journal and book publishers.

See Besen and Raskind, op. cit., footnote 2, pp. 14-16; and S.M. Besen and S.N. Kirby, *Compensating Creators of Intellectual Property: Collectives That Collect* (Washington, DC: Rand Corp., 1989). For descriptions of ASCAP and BMI, see U.S. Congress, Office of Technology Assessment, *Copyright and Home Copying:* Technology Challenges *the Law,* OTA-CIT-422 (Washington, DC: U.S. Government Printing Office, October 1989), ch. 4.

24 *Menell* (1987), op. *cit.,* footnote 15, pp. 1339-1345.

25 Ibid., p. 1340.

26 For an important exception (from the law literature) see Stephen Breyer, "The Uneasy Case for Copyright: A Study of Copyright in Books, Photocopies, and Computer Programs, ’ *Harvard Law Review,* vol. 84, No. 2, December 1970, pp. 281-351. In this article, although unable to conclude that copyright should be abolished, Breyer argued against extending the boundaries of copyright. He also concluded that advocates of copyright protection for computer programs had not yet made their case (in terms of empirical evidence and argument) and that if a need for program copyright was shown, efforts should be made to tailor protection to minimize economic harms to society (pp. 349-350).

27 Winter, op. cit., footnote 8, pp. 41-60.

Box 6-A—Some Software Industry and Technology Changes Since CONTU

Explosive growth in personal computers and packaged software: When Congress created the National commission on New Technological Uses (CONTU) in 1974, the "PC revolution" had not yet begun to bring desktop computing power to the millions of individuals that now use it. But, by the time CONTU issued its final report in 1978, the PC revolution was under way, creating a new generation of computer users who were not primarily programmers or computer experts. The rapid proliferation of PCs in homes, offices, and schools created a very large retail market for application software-for word processing, spreadsheets, even games-as well as a lucrative market for PC operating-system software. Large communities of users are now able to obtain powerful hardware and software tools. This broad base of users permits realization of network externalities; users increasingly exhibit preferences for programs with similar (and/or easy-to-learn) user interfaces.

Because of timing, CONTU and the analyses prepared for it could not really foresee the time when powerful computers could be in every office or every home, or when individuals would be able to create sophisticated and valuable software outside large organizations. There was an intimation of the possibilities, but no way to comprehend their full impact a decade hence:

> [T]here are some individuals who believe that future technological changes will permit individuals to do some programming useful to themselves and potentially valuable to others in their own homes. . .Changes in computer and programming technology may also make possible a degree of do-it-yourself programming by consumers. (Report to CONTU prepared by the Public Interest Economics Center (PIE), June 1977, pp. IV-4, IV-6.)

Increased barriers to entry by small firms: The CONTU report and the economic analysis prepared for it in 1977 by the Public Interest Economics Center noted rapid growth in the "independent" software industry, characterized by ''many small firms and rapid entry into the market, " and also noted the likelihood of continued viability for software as a ''cottage" industry. Today, the software industry remains vigorous and there certainly are many successful and innovative small firms. However—unlike when Lotus and Microsoft were founded-the packaged software market is a huge mass market, not a collection of small networks of hobbyists and aficionados. Moreover, as hardware has improved, packaged software programs have become larger and more complex, increasing the cost of writing a commercial program,

A cottage entrepreneur may still be able to develop an innovative and important program with few resources but his or her own wit and time. But, for that program to have substantial commercial success in the retail market, substantial marketing and distribution resources, including national advertising campaigns and customer-support services, will usually be required. Therefore, there has been a trend toward centralized software-publishing houses that acquire rights to software and then distribute and market it, paying royalties to the program authors.

Maturity of industry and increasing firm size: Once a small firm becomes successful, it appears to be relatively difficult to develop the firm to a meaningful size with the capacity to capture a significant fraction of the

considered that stronger protection for intellectual property was desirable to promote innovation.[28] Theoretical and empirical work from the mid- 1970s to present has challenged the assumption that stronger intellectual property regimes yield positive economic consequences. Moreover, industries have been found to vary in the extent to which rights holders are able to acquire competitive benefits from their ''properties" under the current regime. As Winter puts it:

> . . the desirability of strengthening or weakening invention incentives in a particular context depends on the existing balance (in that context) between (1) the joint effectiveness of a variety of means of appropriating returns and (2) the extent to which the advances in question are actually a net contribution to societv. rather than a capture of wealth from the public domain.[29]

Sometimes strengthening patent protection can produce *excessive incentives* for certain types of

[28] ''Arrow's [1962] article also contained a simple (but seminal) formal model of process innovation. The message of this model was unambiguously that even an ideal system of patents (of infinite duration and costlessly enforceable) might well provide an "inadequate' incentive to invent. . .To the extent that any policy implication is inferable from this very simple economic model of invention, it is clearly in the direction of stronger protection for intellectual property rights, and perhaps other measures to reduce transaction costs in markets for such rights. ' (Winter, op. cit., footnote 8, p. 42.)

[29] Ibid., pp. 41-60 (quote from p. 45). Winter draws his empirical evidence concerning functioning of the patent system from a Yale University study conducted by Richard Levin, Alvin Klevorick, Richard Nelson, and Winter. See R, Levin et al., "Survey Research on R&D Appropriability and Technological Opportunity, ' *Brookings Papers on Economic Activity, 1987,* pp. 783-820.

market and to expand internationally. Part of the difficulty seems to come from the technological nature of the enterprise, A startup is often technology-oriented: the founder may be chief programmer, perhaps designer of a single product. As the firm grows, it needs to shift to a market (rather than technology) focus: advertising, packaging, and user support become increasingly essential. A corresponding increase in personnel may also require the firm to acquire new managerial expertise. The notion that a firm must achieve a certain size and have a certain amount of marketing and managerial savvy in order to be a significant player in the software industry seems to receive support from the increasing number of software mergers and acquisitions.

Acquiring or merging with a company with similar product offerings can be efficient. It maybe less costly to acquire a small firm with a niche product, rather than developing it internally; conversely, once a small niche company has peaked, its logical evolution may lie in being acquired by an established firm, rather than trying to expand. Business alliances with firms that are "complementary" in terms of products, technologies, and market focus can also be very advantageous—the 1991 alliance between IBM and Apple is a notable example.

Increasing concentration: It still seems to be true—but perhaps not so true as in the early 1980s--that the software industry is a haven for small entrepreneurs. One estimate is that there are 9,000 to 12,000 software companies in the United States. However, a closer look shows that the industry is relatively concentrated, dominated by the top 200 companies or so. Distinct segments of the industry illustrate this relative concentration: according to Soft-Letter, the "Top 20" PC software companies reported 1990 revenues of about $3.3 billion. The "Top 5," however, accounted for two-thirds of these revenues, with the "No. l" firm accounting for almost 30 percent of the total (for the "Top 10," see table 3-2 inch. 3).

Prominence of hardware manufacturers as software producers: CONTU saw the software-market shares of hardware producers being ''steadily eroded" by independents and concluded that, with software protection, competition in software would be enhanced in the future due to entry. *(CONTU Report,* p. 24). Despite vigorous growth by the independent software sector, the hardware firms retain a major share of the software market overall. In terms of revenues, IBM is the leading U.S. software producer overall and is the largest packaged software vendor in the world (see ch. 3).

SOURCES: OTA workshop on "Software Developers' Business Needs and Concerns, " Sept. 25, 1990; also Everett M. Rogers and Judith K. Larsen *Silicon Valley Fever (New York:*Basic Books, Inc., 1984); Robert Schware, *The World Software Industry and Software Engineering* (Washington DC: The World Bank, 1989); *Final Report of the National Commission on New Technological Uses of Copyrighted Works (CONTU),* July 31,1978 (referred to by OTA as *CONTU Report); ''AnAnalysis* of Computer and Photocopying Copyright Issues From the Point of View of the General Public and the Ultimate Consumer,' Public Interest Economics Center (Washington DC: June 1977); INPUT, *U.S. Software Products Market, 1988-1993 (Mountain* View, CA: INPUT 1988); Organization for Economic Cooperation and Development *Internationalization of Software and Computer Services* (Paris, France: OECD, 1989); data compiled by *Soft-Letter* (Watertown, MA: 1991).

inventive effort. Private returns from an invention are usually expected to be lower than the benefits accruing to society.[30] However, there are exceptions. For certain types of inventive efforts, private returns may exceed social returns. This might occur, for example, if the inventor is able to invest in complementary assets whose prices will tend to increase after his or her invention is disclosed and implemented. The inventor's gain from these complementary assets need not be related to (or bounded by) the social value of the invention.[31] The possibility for extraordinary returns from inventions with valuable complementary assets might divert inventive efforts from other areas that might be more beneficial to society as a whole, although less rewarding to the individual rights holder.

Another source of excessive incentives for inventive activities comes about from the possibility of multiple inventors. In a dynamic ''race to patent, '

30 Mansfield's 1977 studies comparing average social and private rates of return from investments in innovation in a variety Of industries found that estimated social returns exceeded private ones, usually quite substantially. *IOTA note: This* aggregate approach did not compare public and private returns for particular inventions or inventors.] See Edwin Mansfield, ''Intellectual Property, Technology and Economic Growth,'' in *Intellectual Property Rights in Science, Technology. and Economic Performance,* Francis W. Rushing and Carole Ganz Brown (eds.) (Boulder, CO: Westview Press, 1990), ch. 2, esp. pp. 20-22.

31 Winter, op. cit., footnote 8, pp. 42-43. See also J. Hirshleifer, ' 'The Private and Social Value of Information and the Reward to Inventive Activity, ' *American Economic Review,* vol. 61, 1971, pp. 561-574; and Whinston, op. cit., footnote 18.

new technologies may be implemented too early-it might be better from a social perspective to wait and allow costs to decline due to general technological advance. Also, assuming the possibility of multiple independent discoveries, a patent might be granted for an invention that would otherwise appear in the public domain during the useful lifetime of the patent.[32]

Looking at the interplay of economic growth and patent and antitrust policies, Janusz Ordover has concluded that "weak" patent protection need not hamper economic growth, if appropriate industry cooperation is allowed. At the same time, ''strong' protection need not hinder diffusion of advances:

> Appropriately structured patent law and antitrust rules can together ensure incentives for R&D [research and development] and also induce cooperation among firms in diffusing R&D results through licensing and other means. . .At the same time, cooperation among firms at the R&D stage can counterbalance weak patent protection by internalizing spillovers from ongoing R&D programs, and such cooperation may also produce additional spillovers from existing knowledge.[33]

Ordover's examination of intellectual property and antitrust regimes in the United States, Japan, and the European Community, suggests, however, that the U.S. policy mix may have gone too far in favoring the interests of the inventor:

> . . the current U.S. policy thrust of strengthening patent protection while reducing antitrust restrictions on the exercise of intellectual property rights is not a precondition for high rates of growth and for the maintenance of R&D incentives.[34]

Industry Differences in the Perceived Efficacy of Intellectual Property

The extent to which the effects of intellectual property regimes on market behavior are manifested, as well as the social desirability of these outcomes, may vary depending on the characteristics of the market and technology.[35] In theory, a patent confers perfect appropriability from a technological advance of requisite quality in exchange for public disclosure and widespread use of the advance after the patent term has expired. In practice, patents often do not confer perfect appropriability (e.g., because they can be invented around or are too hard to enforce) and public disclosure of a patent claim need not assure eventual diffusion of the *knowledge* required to make economic use of an advance. Substantial resources may be required to imitate an innovation, even one in the public domain.[36] Moreover, firms may be able to ''pyramid' the benefits they derive from their patents by "fencing in" a field of technology through systematic patenting.[37]

In general, patents are thought to discourage entry into a market by raising the costs of entering with a "close" substitute or by deterring entry entirely, when the costs of licensing or inventing around the patent are too high. By comparison, copyright (which is not intended to bar independent creation)

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32 Winter, op. cit., footnote 8, pp. 43-44. See also Y. Barzel, "Optimal Timing of Innovations," *Review of Economics and Statistics,* vol. *50, 1968,* pp. 348-355; and R.R. Nelson and S.G. Winter, *An Evolutionary Theory of Economic Change* (Cambridge, MA: Harvard University Press, 1982).

A contrasting view is that in some cases, early delimitations of patent rights can be used to make R&D resource allocation more efficient. This is called the ''prospect theory" of patents. See E. W. Kitch, "The Nature and Function of the Patent System," *Journal of Law and Economics,* vol. 20, 1977, pp. 265-290. But see Robert P'. Merges and Richard R. Nelson, ''On the Complex Economics of Patent Scope, ' *Columbia Law Review, vol. 90, No. 4,* pp. 839-916, esp. pp. 871-878.

33JanuszA.Ordover,''A Patent System for Both Diffusion and Exclusion,'' *Journal of Economic Perspectives,* vol. *5, No.* 1, winter 1991, pp. 43-60 (quote at p. 44). Ordover suggests that dichotomies like "long-term v. short-term" and ''exclusion v. diffusion' are too simple to be used as tools to shape public policy concerning patents.

34 Ibid., pp. 44,59.

35 For an equilibrium analysis of the relationship between market structure (including patent terms) and firms' decisions to invest in R&D, see Glenn C. Loury, "Market Structure and Innovation" *The Quarterly Journal of Economics,* vol. *93, No. 3,* August 1979, pp. 395-410.

For analysis of the effects of patent scope on invention, taking into account differences in industrial patterns of technological advance, especially in cumulative technologies, see Merges and Nelson, op. cit., footnote 32, pp. 880-908.

36 Richard C. Law@ ''A New Look at the patent System," *AEA Papers and Proceedings,* vol. 76, No. 2, May 1, 1986, pp. 199-202.

37 See Scherer, op. Cit., footnote 16, ch. 16, esp. pp. 450-452. Scherer also discusses institutional aspects of patent prosecution and administration.

is generally thought to impose lower barriers to entry.[38] In terns of economi, welfare, barriers to entry are not uniformly ‘ ‘bad’ in some cases, they will be beneficial. Analysis of which condition pertains can be quite complex and depends, in part, on whether goods will be produced in excessive variety (relative to the socially optimal amount of variety), absent barriers to entry,[39]

In instances where consumers care little about product variety, theory suggests that barriers substantial enough to reduce the number of very similar products (e.g., patents) will be beneficial. Conversely, when consumers value variety highly, an intellectual property regime that allows multiple products with similar features (e.g., copyright) will be preferred.[40] When consumers place a high value on products with similar features, the value of a copyright (to the copyright owner) will increase to the extent that it allows control over preparation of works with similar features (e.g., allows control of user interfaces).[41]

Under the present patent system, the ability of innovators to appropriate returns via patents appears to differ across industries and technologies.[42] In the 1980s, a multi-industry study on R&D appropriability (the ‘ ‘Yale study’ was conducted by Richard Levin, Alvin Klevorick, Richard Nelson, and Sidney Winter. This research explored industry differences in the perceived effectiveness of patents in gaining and maintaining competitive advantages from new or improved products and processes.[43] The researchers surveyed industry R&D managers concerning the relative effectiveness of:

- patents to prevent competitors from duplicating the new product or process;
- patents to earn royalty income through licensing;
- maintaining secrecy about the new product or process;
- leadtime advantage (from being first out with a new product or process);
- moving quickly down the learning curve (in order to reduce costs); and
- superior sales or service capabilities.

The Yale study concluded that the role of a patent in gaining and maintaining competitive advantage depends in large part on specifics of the relevant industry and technology. For example, in an industry where inventions tend not to be technologically independent of other patented inventions, firms with patent portfolios may participate in patent cross licensing. Even under these circumstances, breakthrough, “pioneer” patents can yield large advantages through excluding others and/or producing royalty income.[44]

The Yale study found a great deal of inter-industry variation in the perceived effectiveness of patents as a means of securing innovative gains, even in ‘ ‘high-tech, ’ R&D-intensive industries:

38 However, some legal observers warn that overly-broad copyright protection for software—e.g., copyright proteCtion for user interfaces—is equivalent to patent protection, except that the protection has been obtained for an extremely long term and without patent criteria of novelty and nonobviousness. (See Pamela Samuelson, ‘ ‘Why the Look and Feel of Software User Interfaces Should Not Be Protected by Copyright Law, ” *Communications of the ACM*, vol. 23, No, 5, May 1989, pp. 563-572.) Others consider that software faces a more general problem in that attempts to apply traditional copyright principles and precedents may well restrict efficient technology development. (See Dennis S. Karjala, ‘‘Copyright, Computer Software, and the New Protectionism,” *Jurimetrics Journal*, fall 1987, pp. 33-96.)

Disagreeing with these views, many other legal observers consider that the courts can be (and generally have been) successful in adapting traditional copyright principles to software cases. (See Morton David Goldberg and John F. Burleigh, ‘‘Copyright Protection for Computer Programs: Is the Sky Falling?’ *AIPLA Quarterly Journal*, vol. 17, No. 3, 1989, pp. 296-297; and Anthony L. Clapes, Patrick Lynch, and Mark R. Steinberg, “Silicon Epics and Binary Bards, ” *UCLA Law Review*, vol. 34, June-August 1987, pp. 1493-1594.

39 See, e.g., Michael Waterson, ‘‘The Economics of Product Patents, ’ *The American Economic Review*, vol. *80, No. 4*, September 1990, pp. 860-869.

40 Waterson, op. cit., footnote 39, pp. 867-869. For analysis of the economic effects of increased copyright protection where consumers vary in their tastes and in their costs of copying, scc Ian E. Novos and Michael Waldman, ‘ ‘The Effects of Increased Copyright Protection: An Analytic Approach, ’ *Journal of Political Economy*, April 1984, pp. 236-246.

41 Michael O’Hare, “Copyright: When Is Monopoly Efficient?” *Journal of Policy Analysis and Management, vol. 4, No. 3, 1985,* pp. 407418. Copyright gives exclusive rights over derivative works, to the extent that protected expression is used.

42 Fo, theoretical analysis of how the preferred form of research incentive can vary depending on market structure, see Brian D. Wright, ‘‘ne Economics of Invention Incentives: Patents, Prizes, and Research Contracts, ” *The American Economic Review*, vol. *73,* September 1983, pp. 691-707. Wright finds that when the probability of success of a project is high, contracts are preferred; when the probability of success is low to moderate and the supply of research is elastic (increases in expected financial rewards attract new researchers), patents are best (ibid., p. 703).

43 Winter, op. cit., footnote 8, pp. 45-56. Sec also R. Levin et al., op. cit., footnote 29, pp. 783-820.

44 In 1958, Machlup noted that strategic patents and/or restrictive licensing can permit substantial control of an industry by blocking or excluding rivals; accumulation or aggregation of patents can bar entry by newcomers. He also noted that ‘‘patent pooling’ (cross licensing) has ‘‘often been the vehicle for cartel agreements of the most restrictive sort. (Machlup, op. cit., footnote 21, pp. 10-12.)

- Patents were perceived as highly effective in the pharmaceutical industry[45] but were rated as being only moderately effective in the semiconductor, computer, and communications equipment industries;
- Most industries reported that using patents to secure royalty income! was less effective than using patents to prevent duplication;
- Except in petroleum refining, patents were considered more effective in preventing product duplication than process duplication;
- With the exception of product patents in the organic chemical and pharmaceutical industries, using patents to prevent duplication was perceived as only moderately effective in securing gains from an innovation.[46]

The Yale study found that the most important perceived limitation to the effectiveness of patents was "inventing around" by rivals able to invent a substitute product or process or narrowly skirt the edges of the patent claims. The fast pace of technological advance (''technology moving so fast that patents are irrelevant") was considered much less of a limitation. Perceived problems of "not readily patentable" subject matter and ''patents disclose too much proprietary information" were more severe for new or improved processes, rather than products. These considerations help explain the importance of other tools—like lead time and secrecy—in securing and preserving competitive advantages .47

The terms under which a patent is licensed depend on a number of factors, including the relative bargaining powers of the patent holder and prospective licensee, and how much information each has about market conditions, the invention, and the economic value of the patent.[48] Patent licensing can provide licensers with other advantages besides royalty income. In some cases, strategic licensing will permit a patent holder to structure the industry so it consists of relatively 'weak' competitors. This structure enables the patent holder to prolong its dominant position after the patent term has expired.[49]

Cumulative Technological Progress

The literature on "patent races" focuses on analyzing situations where multiple innovators are vying to achieve the same goal.[50] A somewhat different set of circumstances arises when innovation is cumulative--one firm develops an initial innovation but others can build on it. In this model, the incentives to develop both the initial and subsequent innovations depend on the scope (breadth) of patent protection.[51] The traditional literature did not focus on the dynamics of cumulative progress and multiple inventors.

Suzanne Scotchmer has looked at use of (product) patent protection and cooperative agreements to protect incentives for cumulative research where initial innovations facilitate subsequent ones.[52] She finds that with ***broad patent protection,*** economic incentives for outside firms to develop second-generation products (under license) can be too weak. The incentives for the frost innovator to develop the second-generation products (assuming he or she has the insight and resources to do so) are much stronger; in some cases, the prospect of licensing revenues for second-generation products may inefficiently inflate

45 In the pharmaceutical industry, a patent often corresponds to one product.

46 Winter, op. Cit., footnote 8, pp. 46-49, especially table 2.1. The study included the computer, semiconductor, and communications equipment industries, but not a separate "software" industry. Winter notes that these findings support both Arrow's view that transaction costs present serious problems for information markets (i.e., patent licensing) and also Kitch's view on the value of patents in making R&D markets more efficient.

47 Ibid., pp. 48-56, esp. table 2.2 and figure 2.1.

4S For discussion of literature on licensing arrangements and analysis of arrangements when the patent holder must decide how much information to share with the licensee, see Nancy T. Gallini and Brian D. Wright, ''Technology Transfer Under Asymmetric Information" *RAND Journal of Economics*, vol. *21, No.* 1, spring 1990, pp. 147-160.

49 For analysis of how a dominant patent holder may prefer to license to technologically weaker competitors, whose presence in the industry may deter entry by other fins, even after the patent has expired, see Katharine E. Rockett, "Choosing the Competition and Patent Licensing, ' RAND *Journal of Economics*, vol. 21, No. 1, spring 1990, pp. 161-171. Rockett cites examples of the development and licensing of polyester, cellophane, and nylon as evidence to support the general assumption that powerful patentholders can use licensing to structure their competition and preserve competitive advantages beyond the patent term.

50 The ''race'' metaphor assumes that only one firm can win the patent and that inventions are discrete.

51 Besen and Raskind, op. cit., footnote 2, p. 4.

52 Suzanne Scotchmer, "Standing on the Shoulders of Giants: Cumulative Research and the Patent Law," *Journal of Economic Perspectives*, vol. *5, No.* 1, winter 1991, pp. 29-41.

incentives for the first innovation.[53] With *narrow patent protection,* first-generation innovators may be discouraged from patenting and disclosing their products (if they fear that second-generation products developed by others will hurt their profits). They might, instead, hold frost-generation products off the market until they had developed their own second-generation products; alternatively, they might rely on trade secret protection to avoid disclosing the nature of their technological advances.[54]

Scotchmer explores two possible remedies for these defects:

> *narrowing the scope of protection* for the first patent (so that 'different enough' second-generation products do not infringe), and
>
> *prior agreements,* whereby second-generation innovators can sell their ideas to innovators of the first products or integrate with them.

She finds that:

> [N]o system of narrower patent protection and licensing can give the right incentives to both the first innovator and other firms that develop improvements, even if collusive licensing among noninfringing products were allowed. . ,[this] result depends on my premise that the breadth of the underlying patent cannot be separately tailored to the costs and benefits of each second generation product.[55]

Scotchmer also finds that—assuming that parties to the agreement can collude in using the resulting patents—prior agreements (e.g., research joint ventures) are:

> [A] social improvement over licensing because they can improve incentives to invest in second generation products, whatever the breadth of patent protection,[56]

She finds, therefore, that there are no simple conclusions to draw about the optimal breadth of patents; moreover, questions about patent breadth must be considered jointly with questions about the extent to which firms will be permitted to cooperate (under antitrust rules). Therefore, Scotchmer concludes that prospects for fine-tuning the patent system for particular technologies seem limited,[57]

Considering further the tradeoffs between disclosure and profitability, Suzanne Scotchmer and Jerry Green examine the effect of the novelty requirement in patenting on information sharing and economic welfare in industries where progress is cumulative .58 Scotchmer and Green proceed from the premise that the *effective* lifetime of a patent may be much shorter than its statutory term—the patented technology may be displaced by a (noninfringing) and superior innovation. Thus the novelty requirement is important in patent design. A high standard of novelty makes displacement harder and, in principle, gives a larger return to the patent holder, However, a high standard of novelty also bears a social cost in that relatively minor incremental innovations may not be patented—thus, not disclosed. High standards may also encourage firms who fall behind technologically to drop out of the patent race. This can be beneficial if it reduces duplicative research by technologically less-advanced fins. When the novelty requirement is weak, these firms may have too strong an incentive to stay in the patent race.[59]

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53 Ibid., pp. 32-33. The prospect of licensing revenues may overinflate incentives for the first product innovation when it is not the only possible way to achieve the second-generation innovations. Scotchmer's analysis assumes that the second-generation product infringes the patent on the first and therefore, some of the second innovation's revenues must be transferred to the first innovator under licensing.

54 Ibid., pp. 38-39.

55 Ibid., pp. 33-35.

56 Ibid., p. 36, Social benefits would be largest if all possible innovators could be integrated via an agreement prior to the first innovation; however, this is likely to be infeasible, particularly in fields where second-generation innovations are serendipitous.
In Scotchmer's model, collusion in use of the patents is an important way to protect incentives to innovate. When research outcomes are unpredictable, innovators cannot know beforehand whether particular projects will result in innovations that infringe an earlier patent; therefore, rules that permitted agreements only if patents turned out to be infringing would be difficult to implement (pp. 36-37).

57 Ibid., pp. 39-40. In Scotchmer's model, patent breadth and term may sometimes be chosen independently; in other cases, breadth and effective term are correlated.

58 Suzanne Scotchmer and Jerry Green, "Novelty and Disclosure in Patent Law," *RAND Journal of Economics,* vol. 21, No, I, spring 1990, pp. 131-146. In their analysis, the patent system's criteria for novelty and nonobviousness determine both how broad the claims of a patent can be and how different subsequent innovations must be not to infringe. Thus, these criteria determine the value of a patent, the incentives for innovative activity, and how much technological information is disclosed and diffused.

59 Ibid., pp. 144-145; and Garth Saloner, "Introduction to Symposium on Patents and Technology Licensing," *RAND Journal of Economics,* vol.21, No. 1, spring 1990, p. 104. Another result from a weak novelty requirement is that firms may prefer not to disclose all of their technological progress, unless they are able to enter into cooperative licensing agreements with firms producing similar products.

In the copyright regime, the dilemma of 'cumulative progress'' is manifested in controversy over the breadth of protection extended to derivative works, Some economists have concluded that narrower protection for the original work will better serve the public interest by providing incentives for others to create derivative works. In the software arena, these commentators consider that making it illegal under copyright to copy in order to tailor programs to users' special needs, or to copy in order to analyze programs for the purpose of improving and enhancing functions, raises the cost of subsequent innovation.[60] Others, however, conclude that granting control of derivative works to the creator of the original work encourages early release of the original work. Otherwise, they argue, proprietors would attempt to secure market advantages by delaying release until they prepared derivatives.[61]

Patents and Trade Secrets

David Friedman, William Landes, and Richard Posner have examined the economics of trade secret law, focusing on the choice between patent and trade secret protection and why the law does not protect against loss of trade secrets through reverse engineering.[62] In their view, although the courts have sometimes thought that trade secret law protects a "lesser' class of inventions (because "no rational person with a reasonable invention would fail to seek a patent' '), this is not the case. Instead, they argue, trade secret law supplements the patent system. Innovators choose to maintain an innovation as a trade secret instead of applying for patent protection when patent protection is too costly relative to the value of the innovation, when the expected economic lifetime of the innovation is expected to be longer than the patent term, or when the innovation may not be sufficiently novel or nonobvious to qualify for patent protection. There are some social costs to this-with trade secrecy, there is no finite term of protection or disclosure in return for protection. However, these costs are somewhat ameliorated because independent invention (and patenting) of the "secret'' is permitted.[63]

Not prohibiting reverse engineering of trade secrets is costly to the extent that proprietors incur additional costs to maintain the secret or make their products hard to reverse engineer. Nevertheless, these authors conclude, the respective costs and benefits weigh against protecting trade secrets from reverse engineering: For one thing, the social costs of enforcing secrecy through the legal system would be high: for example, it could be difficult to prove that a competitor learned a trade secret through reverse engineering rather than through independent research.[64] Perhaps even more importantly, the information disclosed through reverse engineering facilitates incremental innovation.[65] On balance, Friedman, Landes, and Posner consider that more comprehensive legal protection of trade secrets as property, ''would be tantamount to a perpetual patent law without public disclosure," without the economic efficiency advantages of disclosure and limited terms.[66]

Choices in the Optimal Design of Patents

Rewards to innovation can be granted by broad patents of short duration or by patents designed with narrow scope (breadth) but long duration (term). The supply of R&D and other innovative activities is usually assumed to respond favorably to improved prospects for financial reward-i. e., increased incentives are thought to induce additional innovative

60 Besen and Raskind, op. cit., footnote 2, pp. 16-17 (citing Y.M. Braunstein et al., *Economics of Property Rights as Applied to Computer Software and Data Bases, PB-286 787* (Washington, DC: U.S. Department of Commerce, 1977); and R.H. Stem, "Section 117 of the Copyright Act: Charter of Software Users' Rights or an Illusory promise?' *Western New England Law Review*, vol. *7, 1985*, pp. 459-489).

61 Besen and Raskind, op. cit., footnote 2, p. 16 (citing W.M. Landes and R.A. Posner, ''An Economic Analysis of Copyright Law, *Journal of Legal Studies*, vol. 18, 1989, pp. 325-366).

62 Friedman et al., op. cit., footnote 4.

63 Ibid., pp. 62-66. Friedman, Landes, and Posner note that secrecy contrasts with the ''prospect'' theory of patenting, where disclosure serves to head off wasteful duplication of inventive effort (p. 65). See Kitch, op. cit., footnote 32.

64 For discussion of the some of the difficulties of trade secret protection, including contractual and evidentiary problems in enforcement, see Steven N.S. Cheung, "Property Rights in Trade Secrets, " *Economic Inquiry, vol. 20*, January 1982, pp. 40-53.

65 Friedman et al., op. cit., footnote 4, pp. 69-71.

66 Ibid., p. 71.

activities.[67] As Garth Saloner observes, determining the optimal size of the reward that a patent should confer and the optimal design of the patent (breadth, term) depends on the extent to which society wishes to encourage additional innovative activities beyond those that would take place otherwise, absent patents. There is a tradeoff between the social benefits realized through economic stimulation of innovative activities provided by the promise of a patent and the social costs later induced by the market power that a patent confers; the magnitude of these social costs depends on the manner in which innovators choose to patent, license, and otherwise exploit their discoveries.[68] Therefore, Saloner *notes,* normative questions of optimal patent design and positive questions of how firms behave are closely related; both must inform public policy.[69]

Aggregate data on R&D, patenting, and technological progress generally support theoretical findings that patents encourage innovative activities and increase economic welfare .70 But the more detailed theoretical models of optimal patent design will yield different-even contradictory-conclusions when based on different assumptions about the value of patents[71] and the behavior of innovators and markets (see below). Disaggregate empirical evidence to distinguish among these for the purposes of optimizing patent design is lacking. In terms of empirical evidence to support unambiguous ‘ ‘improvements ‘‘ in patent design, we have not moved very far from Fritz Machlup’s conclusions:

> One **important** moral of the argument [about the effects of an extension of patent protection by 1 year] is that no one who thinks it through can be very sanguine concerning the effects to be expected in ‘‘reality’ and certainly, no one cart be at all sure about any of these matters.[72]

Optimal Patent Term

Along with its breadth, the term of a patent is related to its ‘‘strength. (As was discussed earlier, thinking about whether ‘‘stronger’ rights are unequivocally ‘‘better’ has changed.) Economists have a long history of participation in the debate on ‘‘optimal’ patent terms.[73] As Fritz Machlup related in his 1958 review of the patent system:

> The duration of patents has been determined by historical precedent and political compromise. The 14-year term of the English patents after 1624 was based on the idea that 2 sets of apprentices should, in 7 years each, be trained in the new techniques. . . There were all sorts of arguments in later years in favor of a longer period of protection: it should be long enough to protect the inventor for the rest of his life; to protect him for the average length of time for which a user of the invention might succeed in keeping it secret; or for the average time it would take others to come up with the same invention; or for the average period in which investments of this kind can be amortized; and some pleas were made for perpetual coverage.
>
> Economists usually argued for shortening the period of protection: the bulk of inventions are not so costly as to require the stimulus provided by

67 However, Merges and Nelson conclude that, ‘‘Ultimately it is important to bear in mind that every potential inventor is also a potential infringer. Thus a ‘ ‘strengthening” of property rights will not always increase incentives to invent; it may do so for some pioneers, but it will also greatly increase an improver’s chances of becoming enmeshed in litigation. .When a broad patent is granted or expanded via the doctrine of equivalents, its scope diminishes incentives for others to stay in the invention game, compared again with a patent whose claims are trimmed more closely to the inventor’s actual results. ’ (Merges and Nelson, op. cit., footnote 32, p. 916.)

68 Saloner (1990), op. cit., footnote 59, pp. 103-105.

For a development and analysis of different mechanisms to secure rights for innovators (the “innovation patents’’ and the ‘‘l~ovation warrant’’), see William Kingston (cd.), *Direct Protection of Innovation* (Dordrecht, The Netherlands: Kluwer Academic Publishers, 1987). This study was prepared under contract for the Commission of the European Communities, Directorate-General Telecommunications, Information Industries and Innovation.

69 Ibid,

70 For example, see William Nordhaus, *Invention, Growth, and Welfare: A Theoretical Treatment of Technological Change (Cambridge!* MA: MIT Press, 1969); Zvi Griliches (cd.), *R&D, Patents and Productivity (Chicago,* IL: Chicago University Press, 1984); Zvi Griliches, ‘‘*patent* Statistics as Economic Indicators: A Survey, ” *Journal of Economic Literature,* vol. 28, No. 4, December 1990, pp. 1661-1707; and Machlup, op. cit., footnote 21, pp. 76-80.

71 There is extremely wide variance in the economic value of Patents, Griliches reports that, although a few smaller-scale studies have been done subsequently, the only detailed and extensive survey of patent holders was conducted in the late 1950s by Barkev Sanders and associates at the Patent and Trademarks Foundation. Economic gains reported from patents then in current usc were widely dispersed, with a mean value of $577,000 per patent and a median value of $25,000 (current dollars). Economic returns from all patents (including those not in usc or with negative returns) had a mean of $112,000 and a median c1osc to Zero. (Griliches (1990), op. cit., footnote 70, pp. 1679 -1680.)

72 Machlup, op. cit., footnote 21, pp. 70--73 (quote from P. 73).

73 As described by Sidney Winter, the pendulum of opinion **011 the “Optfi~’ term** of protection (e.g., whether increasing or decreasing the term of patent protection would be more socially desirable) has swung back and forth over the years, For his discussion of changes in economics thinking about the term and strength of protection, see Winter, op. cit., footnote 8, pp. 41-43.

> protection for such a long time, and not important enough to deserve the reward that it affords; a much shorter period would provide sufficient incentive for almost the same amount of inventive activity; the period should not be so long as to allow patentees to get entrenched in their market positions; "technology moves now with a speed once undreamed of—its swift march dictates a shortening in the life of a patent. '[74]

The cyclical debate has continued into our time. In the 1960s, following At-row's seminal paper, economists turned to mathematical analyses of the optimal patent term. William Nordhaus extended Arrow's model of incentives for invention, exploring the relationship between the ''size' of an invention (measured as the decrease in unit production cost of a good) and the patent term. Nordhaus then formulated the socially optimal patent term by maximizing social welfare subject to the inventor's behavior,[75] showing that shorter patent lives were preferable to longer ones.[76]

F.M. Scherer interpreted Nordhaus' theory geometrically and showed that (process) patents induce investments in R&D in two ways. The first of these, the ''stimulus effect, was emphasized by Nordhaus. In this role, the optimal patent provides just enough incentive for additional R&D so that the marginal social gain from further cost reductions just equals the marginal social cost. In its second role, the patent persuades investors that competitive imitation will be deferred long enough so that the stream of (discounted) monopoly rents will exceed outlays for investments in additional R&D.[77]

Scherer's model indicated that 'easy' inventions—those yielding big costs savings in relation to R&D resources invested-warranted shorter protection than "hard' inventions, unless the inventor had faced extraordinary risks or had exhibited extraordinary creativity. Scherer concluded that policies tailoring the life of each patent to the economic characteristics of the invention might be accomplished by a flexible system of compulsory licensing, where a patent would expire or be licensed openly at modest royalties after 3 to 5 years, unless the patent holder could show that special conditions warranted longer terms (e.g., market is small relative to research costs, the invention will yield small cost savings relative to research costs). For patents held by dominant corporations with large market shares, Scherer suggested that a presumption of early expiration or open licensing would be appropriate because the firm would have other ways of appropriating innovation gains.[78]

Empirical studies of R&D incentives and rewards suggest that the *useful economic lifetime* of a patent is often far shorter than the statutory term. From a multi-industry survey of R&D fins, Edwin Mansfield found that the effective economic lifetime of most patents is much less that 17 years; moreover, he found that about 60 percent of patented products were successfully imitated by others within 4 years.[79]

Optimal Patent Term and Breadth

More recent analyses have considered breadth, as well as length, as tools with which to craft optimal patent designs. Gilbert and Shapiro examine the tradeoffs between patent term and breadth in designing a patent to provide a reward of a given size,[80] Their model of the flow of profits available to the patent holder assumes a predictable underlying environment and homogeneous products, where the breadth of the patent corresponds to market power—the broader the patent, the greater the ability to increase price over marginal cost. With this model, increasing patent breadth yields a greater flow of profits but also increases the dead weight losses

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74 Machlup, op. Cit., footnote 21, p. 9. The quote about the *swift* pace of technological advance is from 1941. Machlup discusses the implications of changes in patent term on pp. 66-73.

75 See also Morton J. Kamien and Nancy L. Schwartz, "Patent Life and R&D Rivalry," *The American Economic Review,* vol. 64, March 1974, pp. 183-187.

76 Nordhaus, op. cit., footnote 70.

77 Scherer calls this the ''Lebensraum effect.''

78 F.M. Scherer, ''Nordhaus' Theory of Optimal Patent Life: A Geometric Reinterpretation" *The American Economic Review,* vol. *62,* June 1972, pp. 422427.

79 Edwin Mansfield, ' 'R&D and Innovation: Some Empirical Findings, " in Zvi Griliches (cd.), *R&D, Patents and Productivity (Chicago, IL:* Chicago University Press, 1984). (Cited in Scotchmer and Green, op. cit, footnote 58.)

some the question of how much t. reward patent holders requires some assumptions about the elasticity of supply of inventions, designing an economically efficient patent with a given reward does not. See below.

stemming from the patent monopoly .81 Under these conditions, Gilbert and Shapiro conclude that longer patent terms are preferable to broader patents. However, they warn, their assumptions of a stable environment (with predictable supply and demand) and their focus on a single product is critical to this conclusion. Under other circumstances-for example in markets where research is cumulative—an overly long patent might block subsequent innovations by establishing monopoly rights over an entire line of research. In that case, optimal patents would be tailored differently.[82]

Paul Klemperer uses a different model to explore the tradeoff between patent term and breadth in designing a patent yielding a reward of a given size.[83] In his model, entry into the market is free and substitute goods are available. Consumers are assumed to prefer the patented good, but they vary in their demands and their costs of switching to less-preferred goods (either close rivals or goods in a different product class). As the breadth of the original patent decreases, rivals are able to position their substitute goods closer and closer in product space. Conversely, in Klemperer's model, a broader patent corresponds to fewer close substitutes, more market power for the original patent holder, and larger welfare losses.

Klemperer's model yields differing results, depending on how consumers vary in their costs of substituting to close rivals and substituting out of the product class entirely. If consumers face similar costs of substituting rival products (close substitutes) but vary in their costs of switching out of the product class, then Klemperer also shows that the optimal patent is very narrow and long-lived. However, if consumers have similar costs of switching out of the product class but vary in their costs of substituting rival products, then his model shows that optimal patents are broad and short-lived.[84]

"Protection of the general good is found in the limited term and stringent standards associated with patents, the proscription of the protection of ideas under copyright, and the refusal to allow the extension of patents and copyrights beyond their limited scopes. This last matter may be the heart of the concern about the economic effects of program copyright."

Final Report of the National Commission on New Technological Uses of Copyrighted Works (CONTU), July 31, 1978, p. 23.

Compatibility, Network Externalities, and the Installed Base[85]

For many products, the satisfaction a user derives from consuming the good increases as the good becomes more popular. As Michael Katz and Carl Shapiro explain, these positive externalities can arise for a number of reasons, besides the purely psychological, "bandwagon" effect": market size and share may signal product quality to consumers, or product information may be more plentiful or accessible for popular products. Some products, such as computer software and hardware, also exhibit what are called *network externalities,* where user satisfaction is greater, the more popular the network of users. Network externalities-manifested, for example, in users' preferences for 'popular' programs with established user communities, or for programs performing different functions but having similar user interfaces-are much more important now than at the time of CONTU. As the "PC revolution' has taken place, "networks' and their corollary benefits have become much larger.[86] (See discussion of software network externalities in ch. 4.)

Network externalities sometimes arise from a direct physical effect on product quality (e.g., telephones and facsimile machines become more

81 Richard Gilbert and Carl Shapiro, "Optimal Patent Length and Breadth, " *RAND Journal of Economics,* vol. 21, No. 1, spring 1990, pp. 106-112. The dead weight loss comes about because monopoly power permits the patent holder to maximize profits by producing the patented good in fewer quantities, and charging higher prices, than under competition.

82 Ibid,, pp. 107, 111-112.

83 Paul Klemperer, ' 'How Broad Should the Scope of a Patent Be?'' *RAND Journal of* Economics, vol. 21, No. 1, spring 1990, pp. 113-130.

84 Ibid., pp. 126-127; and Saloner, op. cit., footnote 59, p. 104.

85 *OTA note.* A separate OTA report on *Global Standards: Building Blocks for the Future* will be published in early 1992.

86 Peter Menell notes that CONTU ' 'entirely overlooked' network externalities in its analysis and recommendations (Menell, May 1989, op. cit., footnote 13, p. 1066).

In fairness, this is not surprising because of: 1) the relative paucity of economic analysis of network effects prior to the completion of the CONTU report, and 2) the fact that the main sources of these network effects in the computer industry-microcomputers and mass-marketed software-had yet to come into prominence.

valuable, the larger the network of users). Network externalities can also arise from indirect effects—for example, the availability and quality of service can depend on the number of units that have been sold (e.g., well-established products or brands are more likely to have well-developed service departments). In some cases, network externalities occur for complementary products like computer hardware and software-the amount and variety of software available for use with a particular type of computer will increase as the computer itself becomes more popular.

The size of the network giving rise to these externalities depends on whether products produced by different firms can be used together.[87] Looking at markets where network externalities are present, Katz and Shapiro find that firms' choices whether or not to make their products compatible will be one of the most important dimensions of market performance. In many cases, firms will disagree on the desirability of making their products compatible: doing so may raise the profits of some firms while lowering the profits of others, even if total output increases. Katz and Shapiro also conclude that intellectual property laws help determine how compatibility is achieved—through joint adoption of an industry standard (e.g., when patents are strictly and broadly enforced) or through unilateral actions of adapters (e.g., when patents are loosely enforced or narrowly applied) .88

For example, in the absence of legal protection for user interfaces, a firm's private benefits from introducing a new interface may be short-lived, If it is a market success, other firms will be free to adopt it. When they do so, they will share in the network externalities (which are largely due to the originating firm's market success), With protection for user interfaces, a firm can introduce a new interface into the market and begin benefiting from network externalities, without allowing its rivals to participate in the new network.[89] Looking at user interface standards for PC application programs, Menell finds that these considerations might encourage firms with brand recognition to introduce proprietary (noncompatible) product standards, even though adopting compatible standard would increase net social welfare.[90]

Joseph Farrell finds that compatibility and standardization raise difficult economic and policy issues for intellectual property, particularly when network externalities are present. Looking at formal and informal standards-setting processes for computers and software, he concluded that:

> [I]ntellectual-property rules determine the boundaries of what is protected, and thus determine the borders at which fighting, or competition, takes place.[91]

Farrell considers that copyright law protects the useful and valuable ideas in computer software only indirectly, by protecting "ancillary features" (i.e., expression). Moreover, he argues, it can be economically inefficient to protect the latter—sometimes they should be imitated in order to take advantage of network externalities. Therefore, he concludes that a different mix of protection regimes, to protect the useful aspects of software but permit compatibility, would be more economically efficient.[92]

When compatibility is important, especially when network externalities are present, the *installed base* of products and/or training can affect the pace of innovation. Joseph Farrell and Garth Saloner find that when an installed base exists and transition to a new standard must be gradual, the installed base can sometimes inhibit adoption of the new standards by creating ''excess inertia. ''[93] In this situation, early adopters of the new standard will bear a disproportionate share of transition costs. As a result, when

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87 For computer hardware-software markets, the issue depends on whether software produced for use with one brand of computer (or operating system) will run properly on another brand-if so, the brands can be said to "compatible."

88 Michael L. Katz and Carl Shapiro, ''Network Externalities, Competition and Compatibility,' *The American Economic Review,* vol. 75, No. 3, pp. 424-440.

89 Menell (May 1989), op, cit., footnote 13, pp. 1067-1068.

90 Ibid.

91 Joseph Farrell, "Standardization and Intellectual Property," *Jurimetrics Journal*, vol. 30, No. 1, fall 1989, pp. 35-50 (quote from p. 49). As compatibility becomes more important in an industry, Farrell sees formal standardization beginning to predominate, *even* though intellectual property protections may slow this process by increasing vested interests.

92 Ibid., pp. 49-50. Farrell suggests that (depend@ on court interpretation of laws) this mix might consist of a larger role for patent and less reliance on copyright to protect the most valuable aspects of software. See also Menell (July 1987), op. cit., footnote 15.

93 For discussion of the role of the installed base of hardware and software in earlier markets, see Fisher et al., op. cit., footnote 18, pp. 197-204.

important network externalities are present, the switch to a technologically superior new standard may be slower than socially desirable; even when all users intend to switch, they may prefer to wait for others to switch first.[94] But the opposite distortion is equally possible: when the new standard offers early adopters sufficient advantages over the old technology, they may be willing to switch long before a ''network' of users is well-established. As they switch, the new technology becomes increasingly attractive for later adopters, and ''excess momenturn' '-the inefficient adoption of the new technology—may occur, ''stranding' the old standard and hurting the old installed base's remaining users.[95]

In Farrell and Saloner's model, the presence of an installed base and network of users tied to the old technology creates a bias against a new (even superior) technology. Additionally, users who intend to switch may prefer not to be early adopters of the new technology. Farrell and Saloner show that incumbents can exploit these biases for anticompetitive purposes via *anticompetitive product preannouncements* and *predatory pricing.* Premature preannouncements of improved products using the old technology may prevent a new technology from gaining momentum. An incumbent firm may also be able to deter entry by a credible threat of price cuts in response to entry.[96]

The Economics of Copyright and Home Copying

Almost all of the literature discussed so far in this section has operated in a *business* context in examining linkages between intellectual property systems and technological advance, appropriability of rewards to creativity, etc. As we have seen, these linkages are complex. Therefore, the net effects on rights holders and on society from stronger/weaker, broader/narrower, longer/shorter protections are difficult to predict, let alone measure.

Similarly, the effects of noncommercial, private copying by consumers (which OTA calls ''home copying' are also complex and ambiguous. Economic theory suggests that the possible effects of home copying on resource allocation and on society's economic welfare will vary qualitatively, as well as quantitatively, depending on the economic and technological specifics of the industries and markets. Even for one specific type of home copying (e.g., home audiotaping), empirical effects are difficult to estimate with certainty: using survey data to estimate effects on industry revenues or consumer benefits necessarily involves many assumptions and approximations. Because many critical factors are difficult to measure and because choices among assumptions about underlying factors are subjective, even the same survey data can support disparate estimates of the economic effects of home copying. A 1989 OTA study, *Copyright and Home Copying: Technology Challenges the Law, examin*ed issues related to home copying in general, especially home video- and audiotaping. Chapter 7 of that report discussed the economics literature on home copying (i.e., of music and computer software) and reported on empirical analysis of home audiotaping based on an OTA survey of consumer taping practices (see box 6-B for a summary).

94 Joseph Farrell and Garth Saloner, "Installed Base and Compatibility: Innovation, Product Preannouncements, and Predation, ' *The American Economic Review,* vol. 76, No. 5, December 1986, pp. 940-955, Farrell and Saloner use as an example the persistence of the "QWERTY' keyboard in the face of the ergonomically more efficient Dvorak keyboard.

95 Ibid., pp. 941-942.

96 Ibid,, 954. Predation and anticompetitive preannouncements have been alleged in antitrust litigation, but are hard to prove (p. 942). Also, several economists maintain that truthful preannouncements arc procompetitive because they provide new information to the marketplace. (See Fisher et al., op. cit., footnote 18, p. 289.)

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Box 6-B—Literature on Home Copying

Prompted in large part by the copyright debates of the 1970s and 1980s concerning home audio- and videotaping, several economists have examined the economics of home copying: the effects of copying on the supply of copyrighted works (e.g., prices, quantities, variety), on consumer demand (e.g., whether copies substitute for purchases), and on society's net economic welfare (e.g., whether copying is economically inefficient, whether there would be an "excessive" variety of works absent copying). Because the economic effects of copying are complex and often ambiguous, each of these analyses relies on simplifying assumptions or specific conditions in order to reduce ambiguity. Therefore, the literature must be interpreted in light of the corresponding assumptions and conditions.

The Effect of Private **Copying on Economic Welfare**

Because intellectual property is a public good, ordinary market forces will not necessarily produce the most desirable social outcomes. Chanting a limited monopoly (e.g., via copyright) attempts to balance distortions arising from the partial inability of creators to exclude all nonpayers from obtaining their works. According to this rationale, the inability of creators to appropriate returns from their intellectual property would otherwise result in the underproduction of new works.

In the long run, the effect of unlimited private copying on society's economic welfare is ambiguous. As Johnson (1985) discusses, the long-run effect depends on a number of factors, including relative costs (of producing a home copy versus another "original"), the degree to which copying affects the demand for originals, the degree to which copying affects the production of new works, and the degree to which consumers value additional variety. The net social welfare effect of copying has two components: the effect on producers and the effect on consumers. Changing the amount of private copying (either increasing or restricting it) will affect not only the net level of society's economic welfare, but also the relative balance between producer and consumer welfares.

For example, Besen (1986) notes that copying can increase consumer welfare and producer profits in the short run-if private copying is efficient and the price of originals can be raised to reflect the value of the copies. On the other hand, copying may cause producers to reduce prices; this decreases both consumers' and producers' welfare. If, however, copying (by reducing the number of originals produced) reduces 'excessive' variety, this can increase welfare in the long run. This balance between gains and losses for producers and consumers is often the most visible and most hotly contested issue in debates over copyright scope and enforcement.

Will increased copyright protection for goods like musical recordings and software increase or decrease society's economic welfare? Overall, the economics literature indicates that the implications of increasing copyright protection are complex, and the policy tradeoffs are not simple. Some claim that stronger copyright protection will decrease the loss to society from the ***underproduction*** of works but will increase the loss to society from ***underutilization*** of these works. As Novos and Waldman show, the net result depends on the specifics of each situation. In some cases, market outcomes—where different classes of consumers are charged different prices of a good (e.g., individual and institutional subscription rates for journals) or where copyable and noncopyable goods (e.g., computers and software) are bundled-may be preferable to increased government enforcement, from an economic perspective. In some instances, as Katz notes, home copying might generate benefits from "network externalities" relating to the fact that consumers tend to value a hardware/software system more, the more popular that system and compatible ones are (a larger user base can increase the amount of information available about the system, enhance the image of a popular product, etc.)

Appropriability and Pricing

Private copying need not be harmful to producers, if copying is efficient and if producers can increase prices to take into account the value of the copies that will be made. If not all consumers copy, or if consumers vary in the number of copies each makes from an original, then efficient pricing would require discriminating among these groups, charging them different prices according to their valuations of the originals, based on their ability to make copies. This type of price discrimination is usually infeasible, however, because it is costly and difficult to gather the necessary information on users' valuations of originals and because resale is allowed. The inability to practice perfect price discrimination among users can produce imperfections in markets for intellectual property.

A simplified form of price discrimination is two-tiered pricing, in which producers are able to segment their customers into two classes and maximize profits by charging each a different price. Looking at the effect of photocopying on the number of scholarly journals purchased, Liebowitz has examined journal publishers' ability to indirectly appropriate copiers' true valuation of originals through higher subscription prices to libraries and institutions. He concluded that publishers can indirectly appropriate revenues from copiers who do not directly purchase journals. Since copying may have different effects on other media, however, case-by-case empirical investigation of the institutions and markets involved may be necessary.

Price Discrimination, Resource Allocation, and Variety

The inability to charge different classes of consumers different prices for a good in intellectual property markets means that the prices consumers pay need not reflect their actual valuations of the good: some value the good more, and will be willing to pay more. Those who do not value the good at a given price will not consume it. If they could be offered a lower price reflecting their valuation, however, then they would purchase it and both producers and consumers would be better off. Moreover, the decoupling of prices and valuations makes resource allocation—decisions about what to produce—more difficult and markets less efficient. Besen's analysis for the 1986 OTA report noted that where there are many producers of competing types of intellectual property, the resulting market structure is one of monopolistic competition: firms will have some control over the prices they can charge because their products are differentiated (e.g., music by different recording artists or groups). When firms are unable to charge different consumers different prices, however, there may be either excessive or insufficient variety. Under these conditions, when private copying serves to reduce the variety of products being offered, it does not necessarily reduce the efficiency of supply or make consumers worse off.

SOURCES: U.S. Congress, Office of Technology Assessment, *Copyright and Home Copying: Technology Challenges the Law, OTA-CIT-422 (Washington, DC:* U.S. Government Printing Office, October **1989),** ch. 7; William R. Johnson, "Estimating the Effect of Copying on the Demand for Original Creative Works," contractor report prepared for the Office of Technology Assessment (Springfield, VA: National Technical Information Service, October 1989); Michael L. Katz, "Home Copying and Its Economic Effects: An Approach for Analyzing the Home Copying Survey,' contractor report prepared for the Office of Technology Assessment (Springfield, VA: National Technical Information Service, October 1989); Ian E. Novos and Michael Waldman "The Emergence of Copying Technologies: What Have We Learned?" *contemporary Policy Issues,* vol. 5, July 1987, pp. 34-43; Stanley M. Be- "Economic Issues Relating to New Technologies and Intellectual Property," contractor report prepared for the Office of Technology Assessment by the Rand Corp. (Springfield, VA: National Technical Information Service, 1986); Stanley M. Be- "Private Copying, Reproduction Costs, and the Supply of Intellectual Property," *Information Economics and Policy, vol. 2, 1986,* pp. 5-22; William R. Johnson "The Economics of Copying," *Journal of Political Economy,* vol. 93, No. 11, 1985, pp. 158-174; S.J. Liebowitz, "Copying and Indirect Appropriability: Photocopying of Journals," *Journal of Political Economy,* vol. 93, No. 5, 1985, pp. 945-957; Ian E. Novos and MichaelWal&naq''The Effects of Increased Copyright Protection: An Analytic Approach" *Journal of Political Economy,* vol. 92, No. 2, April 1984, pp. 236-246; and Walter Y. Oi, "A Disneyland Dilemma: Two-Part Tariffs for a Mickey-Mouse Monopoly," *Quarterly Journal of Economics,* February 1971, pp. 77-94.