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Abstract:
This paper was prepared as a companion to the Mattioli Lectures delivered by Hal R. Varian, "Economics of Information Technology," available at: http://www.sims.berkeley.edu/~hal/Papers/mattioli/mattioli.pdf. Professor Varian's overview analyzes a variety of competitive strategies used by high-tech companies. These strategies—such as personalized pricing, lock-in, and the adoption of uniform compatibility standards to fuel bandwagon effects—often rely on intellectual property, typically copyrights or patents. Since Professor Varian does not explore this issue at length, we complement his work by focusing on it.

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Intellectual Property, Competition, and Information Technology*

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1. Introduction

Professor Varian's overview, the "Economics of Information Technology," analyzes a variety of competitive strategies used by high-tech companies. These strategies—such as personalized pricing, lock-in, and the adoption of uniform compatibility standards to fuel bandwagon effects—often rely on intellectual property, typically copyrights or patents. Since Professor Varian does not explore this issue at length, we complement his work by focusing on it.

First, we give a few examples to illustrate how profoundly intellectual property rights influence competitive strategy in the information technology sector**.**

Like most computer software companies, Microsoft uses copyrights, patents, and secrecy to protect its software programs (notably Windows and Office), worth tens of billions of dollars. Microsoft uses all three of the primary strategies discussed by Professor Varian: price discrimination, lock-in, and exploitation of network effects through the control of proprietary interfaces. Copyright protection strengthens Microsoft's incentives to develop and improve its software, and gives it some control over the interfaces between its desktop software and other software, such as middleware and applications software running on Windows, and interfaces with operating system software that runs the powerful server computers that connect with desktop machines in complex computer networks.

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Copyright protection is also important to the modern music and movie industry. Of course there was an entertainment industry before copyright—rivals are said to have sent stenographers to Shakespeare's opening nights, and even Dickens (as a foreign author) did not get copyright protection in the United States until 1891. But the modern industry sells its products in forms that are often *technologically* very easy to copy. If anyone who buys a CD could legally make dozens or millions of digital copies, the music studios such as Sony, Disney, Universal, and Bertelsmann could not extract a significant fraction of the public's true value for a recording; and the same applies to movies.[1] Although such copying is illegal, enforcement is imperfect, so the music labels and the movie studies are gravely concerned about copying in the digital age. Hence they pursue "digital rights management" ("DRM"), building in technological barriers to supplement the legal ones. Controversy has ignited over whether DRM goes too far beyond preventing sheer piracy and prevents other, desirable uses that would otherwise be considered "fair use." We discuss this further in the copyright section below.

Often, desirable uses are mingled with piracy. For instance, the peer-to-peer file sharing system Napster undoubtedly facilitated piracy; yet it also created a cheaper, more flexible distribution system than the costly traditional physical retail distribution of CDs that bundle multiple songs. The music companies asserted their rights under copyright law to shut down Napster. Just as one might have hoped, they did not want to throw out the efficiency benefits of music downloading, and legal music downloads (typically not for free) are now a rapidly expanding business. Likewise, several movie studies recently formed a joint venture, Movielink, to promote a web site offering legal (again, not for free) movie downloads.

The music labels and movie studios, of course, are just one layer in the entertainment value chain. Two other layers that raise interesting information technology and copyright issues are the retail distributors and the artists themselves. Traditional retail distribution is being challenged in many industries by Internet-based (or even phone-based) ordering with shipping

[1] Limited sharing, as in libraries, might not cause a problem, if it proportionately raises the sharing entity's willingness to pay (because it makes a group purchase). Indeed, one could argue that this is the basis of movie theatres: the theater buys a showing right from the studio, and its willingness to pay is based on collecting from the audience. See for instance Hal Varian, "Buying, Sharing and Renting Information Goods," *Journal of Industrial Economics* vol 48 no 4 (December 2000) 473-488.

direct to consumers. Information technology makes that process much more efficient, and also enables services such as Netflix's or Amazon's personalized recommendation services. In the case of goods that *are* information, such as music and video entertainment, the shipping component can also become very easy and cheap. Meanwhile, though, information technology also makes traditional retail distribution (especially inventory control) more efficient.

Information technology alters competitive conditions among artists, both horizontally and vertically. Horizontally, information technology may strengthen an increasing-returns "superstar" effect. There are many good tenors, and in the old days hundreds of them could fill concert halls on any given evening, even if Caruso was the household name. Now, the public identifies "tenor" with three performers (Jose Carreras, Placido Domingo, and Luciano Pavarotti) to such a degree that the FTC charged Vivendi and Warner with violations of the antitrust laws for restricting competition for audio and video compositions involving "The Three Tenors."[2] Vertically, information technology might work in an opposite direction, enhancing competition and lowering entry barriers by enabling start-up bands to get their output to an international niche audience and perhaps grow from there. In movies, a $500 digital camcorder and a website can expose a novice movie-maker's work to niche audiences worldwide. Of course, performers have always been able to expose their work to small audiences—but performing in a café draws a small audience from the neighborhood, while performing on the Internet draws a (perhaps small) audience from around the world, so that much more specialization is possible. Many artists certainly hope that the enormous potential of the Internet as a distribution vehicle, combined with its ability to enable stronger and more precisely targeted word-of-mouth, will erode the power they see being held by the large distribution companies. The hope that information technology will erode the cut taken by intermediaries is shared by authors and other types of artists.

Turning to patents, information technology firms such as IBM, Intel, Hewlett-Packard, and Motorola receive hundreds, if not thousands, of patents each year. They may use their patent portfolios offensively to keep out competitors in certain market niches, defensively to negotiate

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[2] In the Matter of Polygram Holding, Inc.; Decca Music Group Limited; UMG Recordings, Inc.; and Universal Music & Video Distribution Corp., Docket No. 9298, http://www.ftc.gov/os/caselist/d9298.htm.

cross licenses with other firms holding their own patents, or as profit centers by entering into licensing agreements that generate substantial revenues. As the number of patents has grown, and as licensing revenues have multiplied, patents are playing an ever-growing role in competitive strategies in the semiconductor and computer hardware and software industries. The role of patents in these industries appears to be very different from the conventional single-innovation economic literature on patents and patent races, which may more accurately describe pharmaceuticals. While pharmaceuticals are not information technology, they too illustrate how intellectual property supports price discrimination, in that case largely among countries.

Of course, intellectual property rights have long played an important role in industries experiencing rapid technological change. Famous patent disputes arose involving sewing machines, the telegraph, the airplane, and the telephone, to name just a few. And copyright protection has always been important in the publishing industry. But intellectual property rights inherently play a bigger role in establishing competitive advantage in the industries at the heart of the information economy than they did in the agricultural and industrial sectors that used to dominate the economy.

In an agrarian economy, returns accrued to those who owned fertile land, who had the ability to transport agricultural products efficiently to market, and who had sufficient access to capital to withstand unfavorable weather or sharp price fluctuations. Intellectual property, most often in the form of know-how, was important, but such know-how was widely diffused and thus not usually a major source of competitive advantage. Even here, however, intellectual property and similar issues arose. The spice trade was hugely profitable and countries tried to prevent others from getting seeds. In modern agriculture, hybrid and engineered seeds (most famously, Monsanto's "Roundup Ready" soybean seeds that are resistant to Monsanto's Roundup pesticide) are protected by intellectual property rights, as are some pesticides, etc.[3]

In the industrial economy, sustainable competitive advantage often revolved around access to low-cost natural resources, control over large manufacturing facilities subject to substantial

[3] The whole issue of how patent rights involving genetics will be defined and used is terribly important, although outside the scope of this paper.

economies of scale, efficient distribution and marketing, and the ability to manage a large organization with broad geographic reach. While know-how has always been an important source of competitive advantage among manufacturers, and product and process innovations have played a big role in many industries, we would argue that intellectual property rights (especially copyrights) were not as central in the industrial economy as they are in the information economy, where many of the most successful enterprises rely heavily on intellectual property rights to protect their market positions. As a leading example, in the software and information content industries the traditional industrial barriers to entry listed above are lower than in the manufacturing sector and the threat from imitation is more severe.

In this essay, we complement Professor Varian's analysis by showing how intellectual property rights intersect with the competitive strategies he studies. We then build on this observation by exploring how firms are acquiring and asserting intellectual property rights to gain commercial advantage. This leads us naturally into a discussion of whether the existing intellectual property regime functions as intended – to stimulate innovation and thus promote long-run competition – or whether the system is out of balance, granting excessive intellectual property rights, and could be improved so as to avoid retarding innovation and/or harming consumers.

Our essay is organized as follows. First we provide an overview of the basic elements of the intellectual property legal regime in the United States, briefly describing the economic rationales and legal regimes covering copyrights, patents, and trade secrets. We next explain why intellectual property rights underpin each of the competitive strategies studied by Professor Varian. We then move beyond those strategies to look more closely at how the patent system currently is working, and not working, to promote innovation and competition. We close with some observations on possible reform of the patent system.

2. Patents, Trade Secrets, and Copyrights

The intellectual property rights of most interest to economists are copyrights, patents, and trade secrets.[4] Each form of intellectual property has its unique characteristics and role to play.

The United States Constitution provides explicitly for copyrights and patents. The enabling provision (Article I, §8) states that: "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 Writings and Discoveries."

A. Copyrights

We are all familiar with copyrighted works such as books, musical compositions, or movies. Copyright is meant to protect the particular *expression* of an idea. Compared with patents (see below), copyrights are "narrow" in the sense that they do not prevent others from creating or distributing similar works: the copyright on one movie does not prevent others from making movies with similar themes or plot lines. In this sense, copyright law is designed to protect literal copying of creative works – publishing an author's book without his or her permission, or distributing a musical performance over the Internet without the permission of the music company that owns the copyright to that performance. Copyrights may be thought of as granting "mini-monopolies," in the sense that a single book or song has a "monopoly," i.e., represents a unique, differentiated product. Nevertheless, historically, copyrights have not conferred a great deal of market power: there are many substitutes for any given book or piece of music, and when copyrights have threatened to confer a lot of market power, their protection is often weakened.[5]

While copyrights are quite "narrow," in the sense just described, they are very long lived. In 1998, the U.S. Congress passed the Copyright Term Extension Act (CTEA), under which most

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[4] Trademarks, another form of intellectual property, are most relevant for issues involving brands, reputation, and consumer information. We do not discuss trademarks in this essay.

[5] See Peter Menell, "Envisioning Copyright Law's Digital Future," *New York Law School Law Review*, vol. 46, pages 63-109 (2003). Incidentally, the same is true for trademarks. While it is very easy to obtain a trademark – one does not have to establish any innovation to qualify – the resulting trademark may be weakened or even lost if significant market power results. When a brand name such as "Kleenex" becomes "generic" it is no longer protected.

copyrights run until 70 years after the author's death. Previously, under the 1976 Copyright Act, most copyrights lasted until 50 years after the author's death. Congress has repeatedly extended copyrights; back in 1790, copyright protection lasted for only 14 years, renewable for a second 14 years, after which the work would enter the public domain. Sadly, these extensions have typically included copyrights *already issued*, which is extremely hard to justify on the basis of encouraging or rewarding creative works. After all, once works lose their copyright protection they enter the public domain and are more readily available for others to use and build upon. Evidently, the U.S. Congress has been influenced by pressure from holders of copyrights on valuable works that were nearing expiration. (An example often cited is Disney and the copyright on Mickey Mouse.) Nevertheless, the CTEA was upheld by the U.S. Supreme Court, which ruled that, while perhaps dubious as a matter of public policy, retroactive copyright extensions were consistent with the Constitution.[6]

Although some have argued that the law has escaped this problem, there is a risk that when copyright law is applied to computer software some of these long-lived copyrights confer far more market power than copyrights on books or music ever did, and far more than is appropriate given the contribution of the copyright holder.[7] This is for two reasons. First, copyrighted computer software, such as Microsoft Windows, can have far greater economic significance than any single book, musical composition, or movie. Second, copyrights can interact with network effects/interfaces and turn what might initially have been rather "arbitrary" choices (with many alternatives) into "essential" choices (with no good alternatives) once users standardize on a product or interface. The greatest power seems to result when the design choices protected by copyright define an *interface* that lets other software be compatible with the copyrighted software in question. If network effects are strong, a copyright including interface protocols can thus confer a good deal of market power.

For example, in the early 1990s the Lotus 1-2-3 spreadsheet software was widely used—indeed, some called its early versions the PC's first "killer app." Borland offered a rival spreadsheet,

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[6] Eldred vs. Ashcroft, U.S. Supreme Court, Decided January 15, 2003; available at http://www.supremecourtus.gov/opinions/02pdf/01-618.pdf.

Quattro Pro, that emulated the Lotus user interface and offered "macro compatibility" so that users could transfer their own programs (macros) written for Lotus 1-2-3 to Quattro Pro. Lotus sued Borland for copyright infringement, and initially won, but the Supreme Court upheld (equally divided and without comment) an appeals court ruling that Lotus's copyright did not enable it to stop Borland from emulating the user interface.[8] Many observers (including one of us) had argued for this result because the user interface, even if arguably initially arbitrary "expression," acquired *ex post* market power as users saved important spreadsheets, learned to use the product, and crafted macros.[9] Both in the US and in Europe, there are now fairly extensive rights to reverse engineer and copy software so as to achieve compatibility, both for complements and for substitutes.[10] Even the Digital Millennium Copyright Act ("DMCA") (section 1201(f)) recognizes this right.

To cite another important example, Microsoft's copyrights on Microsoft Windows and on Microsoft Office cannot prevent others from making operating systems or productivity suites with similar features or functionality, but they can, especially combined with secrecy, prevent others from copying some of the file formats or other interfaces associated with these widely used programs. Indeed, Microsoft places great value on its ability to protect the interface between its Windows operating system running on desktop computers and operating systems running on servers. Microsoft fought vigorously in its antitrust case with the U.S. government to limit any duties imposed on it to open up or license the Windows program interfaces.[11]

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[7] See Menell, op. cit., both for the argument that copyright law has sorted this out and for some of the mis-steps along the way.

[8] The lower court decision is 49 F. 3d 807 (1st Circuit, 1995); the (uninformative) Supreme Court ruling is at 516 U.S. 233 (1996).

[9] See "Amicus Brief of Economics Professors and Scholars in Support of Respondent, " available at http://elsa.berkeley.edu/users/woroch/amicus.txt. To economists, an odd feature of the case was that *Borland* argued that *Lotus* had put considerable research and effort into the design of its user interface. While this would if anything have helped Lotus had it been a patent case, in a copyright case this helped Borland argue that there were no comparably efficient alternative interfaces, so that if Lotus got copyright protection on the interface, that would give it market power in a way that copyright is not meant to do.

[10] See for instance Pamela Samuelson and Suzanne Scotchmer, "The Law and Economics of Reverse Engineering," *Yale Law Journal* vol 111 (2002) .

[11] Unhappiness with Microsoft's licensing program regarding interfaces between the desktop and servers recently erupted (in early 2004) as the Department of Justice told the Court overseeing its settlement with Microsoft that it was not satisfied with Microsoft's performance in this area.

As these examples illustrate, the scope of copyright protection can have very significant implications for competition and innovation. More examples can be found in the debate surrounding the proper copyright treatment afforded to databases since the Supreme Court's 1991 *Feist* decision, holding that some creativity must go into the creation of a database for it to qualify for copyright protection.[12]

We are currently witnessing a very active debate over the role of copyright, and whether copyright law must change, in the digital age. On the one hand, certain rights holders express grave concern that modern information technology is permitting piracy to become rampant, and that the Internet is serving as "one giant copying machine" that steals creative material from authors, composers, and artists. These people seek to mandate technologies that would prevent or limit unauthorized copying of copyrighted works. They also seek broad powers to identify individuals engaged in copyright infringement, and stiff penalties for those found to have used copyrighted materials without permission. At the same time, many other observers express concerns that copyright law is serving us poorly in the information age as rights holders use technology to prevent innocent or socially desirable uses of their works that would otherwise be perfectly legal. These critics assert that copyrights now confer too much power, either to control how works are used or to keep works out of the public domain for many years, and that "fair use" is being defined too narrowly.[13] Napster not only threatened music studios' intellectual property: it was also innovative in its own right.

Both sides in this debate predict a decline in creative activity. But one side predicts that this decline will result as widespread piracy undermines the incentives to create, while the other side predicts that the decline of creativity will result from sharp limits on the public's ability to use copyrighted works and a greatly reduced public domain. These points of view need not be empirical *alternatives*: it could well be that information technology does indeed encourage piracy

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[12] See Feist Publications vs. Rural Telephone Service Co., 499 US 340. In *Feist,* a simple list of names and addresses did not merit copyright protection. See http://www.copyright.gov/reports/dbase.html for a summary of the issues in this area as of 1997.

[13] For a recent and entertaining summary of this growing criticism of the copyright system, see "The Tyranny of Copyright," by Robert Boynton, *New York Times Magazine,* 25 January 2004. See also Charles Mann, "Who Will Own Your Next Good Idea", *The Atlantic Online*, September 1998, available at http://www.theatlantic.com/issues/98sep/copy.htm.

and that this is inefficient, *and* that digital rights management allows and encourages copyright holders to limit the use of digital works in ways that stifle complementary creativity and go far beyond limiting piracy (even though the holder of a clear property right does not usually want to limit complementary innovation *as such*). A key question would then be whether some more "refined" public policies than (for instance) the widely-criticized DMCA could stem piracy without forcing or encouraging copyright holders to impose other, socially (and possibly privately) undesirable, restrictions.

This debate has generated a great deal of heat, and rather less light. At its worst, media companies complain of rampant and irresponsible piracy while seeking retroactive copyright extensions, and digital freedom fighters claim that "information wants to be free" and rail against corporate greed. As economists, we hope we can take the debate in a more constructive direction by identifying more carefully crafted policies that control piracy without curtailing fair use or greatly shrinking the public domain. But we must recognize that the two polar viewpoints do conflict at the policy level, if there are no such policies. They also represent a fundamental clash of views about the sources of innovation and creativity.

The *incentives school* focuses on whether an innovator can capture a large portion of the benefit of his or her creation. Implicitly, this school thinks of innovation that is "one percent inspiration, ninety-nine percent perspiration" (to quote Edison). Perspiration will be more forthcoming if it is well paid. Moreover, it may not much matter whether a hundred people (or firms) have strong incentives, or whether just one does: if anyone has a strong enough incentive to sweat, he or she will do so. On this view, innovative efforts, like many other investments, are driven primarily by the return they can generate, after adjusting for risk. It seems fair to say that this school of thought has the ascendancy in policy circles these days.

The *openness school*, by contrast, thinks that it somewhat misses the point to focus on a few firms' incentives for working harder. First of all, there are incentives—often quite strong—for innovation and creativity quite aside from intellectual property. At the level of firms, innovation can help build reputation, and achieve time-to-market advantages: indeed, a widely cited survey of corporations found that intellectual property is seldom firms' primary means of achieving

rewards for innovation.[14] At the level of individuals, invention—which can be fun and/or easy once inspiration strikes—can be rewarding in career advancement social recognition, or self-esteem. And, the openness school argues, it is important that many independent minds work on any given problem, because the next creative idea could come from anywhere. This school of thought is represented by such advocates as Lawrence Lessig, who argues powerfully for an "innovation commons" in his book, *The Future of Ideas*, and who helped found the "Creative Commons" (http://creativecommons.org/) to promote this concept through innovative licensing schemes. The openness school stresses the role of the public domain and fair use in spurring creativity.[15]

Surely this clash is an empirical matter: presumably some kinds of innovation, in some industries, demand strong incentives, and perspiration may be straightforward, if uncomfortable. For those cases, which might include for instance modern pharmaceutical development, the incentives school probably has the stronger position. Other kinds of innovation, perhaps in other industries, are fun and creative, or the byproduct of other activities attractive in their own right, and — once inspiration strikes — do not demand strong financial incentives. Perhaps there are many industries where current copyright protection goes too far, in that greater openness and weaker protection would do far more to increase the supply of creative works (by expanding the

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[14] See R. Levin, A. Klevorick, R. Nelson, and S. Winter, "Appropriating the Returns from Industrial R&D," *Brookings Papers on Economic Activity,* 1987, 783-820. More recently, see Wesley Cohen, Richard Nelson, and John Walsh, "Protecting Their Intellectual Assets: Appropriability Conditions and why U.S. Manufacturing Firms Patent (or not)," National Bureau of Economic Research Working Paper 7552, 2000.

[15] As economists, we see "fair use" as limiting the package of rights that are granted to a copyright holder. Following the Coase Theorem, one can ask whether the assignment of such rights matters, and whether private parties should be permitted to enter into contracts that restrict or expand the rights of those using the copyrighted materials. The initial assignment of rights affects the return to creating copyrighted works and thus has efficiency consequences. One many also view fair-use doctrine as similar to the law on interpretation of private contracts: by assigning rights that "most" parties will want to agree to anyhow, the law can save on negotiation and transaction costs, including costs due to strategic manipulation such as hold up. In this interpretation, fair use should be the best estimate of the court, or the legislature, of what most copyright holders and buyers/licensees would have agreed on had they bothered to negotiate the relevant terms. But this perspective omits the interests of third parties, as do some explicit terms in copyright licenses. For example, consider a software product whose "shrink-wrap agreement" forbids licensees to publish reviews, or at least negative reviews, of the product. (We are told that Autonomy Systems, which describes itself as "the leading provider of software infrastructure that automates operations on unstructured information," www.autonony.com, uses such provisions in some of its software licenses.) Because third parties are affected, i.e. because of informational externalities, one can argue that certain rights of copyright licensees should be inalienable. We do not explore this area further here.

public domain and the scope of fair use) than it would do to reduce the supply of creative works through a direct incentive effect.

We can illustrate the theoretical ambiguity with a modest sketch of a model. Suppose that a single firm's probability of developing an innovation is $p(x)$ if its reward for success would be x. Presumably the function p is increasing, but it might be either concave or (in some range) convex. Concavity would indicate that there are diminishing returns in the probability of success by a single firm as a function of the prize from successful development. Convexity would correspond to increasing returns. But the shape of p is not the end of the story, because it is socially valuable to have at least one firm develop the innovation, but the gains from a second, third, or ninth discovery of the same innovation are far smaller, perhaps zero.[16] For simplicity let us assume that duplicative discovery is valueless, so that policy should aim to maximize the probability that *at least one* firm develops the innovation. If different firms' discoveries are statistically independent, then this probability is given by: $T = \prod_i (1 - p(x_i))$.

Now consider the broad sweep of "incentives" versus "openness" policies. We might interpret "incentives" policies as aiming to maximize the maximum among firms' incentives: it is important that someone have a strong incentive to work hard, but since invention need only happen once, it need only be one firm. On the other hand we might interpret "openness" policies as aiming to maximize the number of firms who have a prospect—perhaps loosely interpreted as some minimal threshold of incentive—for innovating. While it does not necessarily correspond to any specific policy choice, we can try to sketch the tradeoffs by thinking of total incentives—the sum of all firms' values of x—as constrained to be no more than some sum, X.[17]

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[16] In reality, duplicative discovery may sharpen product-market competition relative to single-firm discovery, and if different firms discover different "versions" of the innovation there may be further benefits. Still, it seems likely that the incremental benefits decline sharply with the number of independent discoverers.

[17] Notice that in an ideally functioning system, everyone would have x equal to the full social contribution of their innovation (relative, of course, to the but-for world, which might involve someone else innovating). Thus the total of all values of x might be very large. We are assuming here, to the contrary, that giving one party more incentive comes at the cost of reducing opportunities or incentives for others. We also are not tracking the costs associated with the innovative efforts of the individuals or companies who may make this discovery.

Thus we formalize the policy problem as choosing the values x_i for firms $i = 1, 2, \ldots N$, subject to the constraint that the x_i add up to no more than X, so as to maximize T. This is equivalent to minimizing the logarithm of $[1 - T]$, which is the sum of $\log[1 - p(x_i)]$. Therefore if $\log[1 - p(x)]$ is convex in x, it pays to focus the incentive and give some firm as strong an incentive as possible (that is, $x_i = X$ for one i and $x_j = 0$ for the rest). If $\log[1 - p(x)]$ is concave in x, it pays to spread the incentive and set $x_i = X/N$ for all i.[18]

The incentives school has shown how digital technology can be used to engage in widespread copyright infringement. On both equity and efficiency grounds, such piracy should not be ignored. And no economist could deny that reducing the financial return to producing creative works will, *ceteris paribus*, tend to reduce the supply of creative works. By the same token, however, the openness school has done a good job of illustrating the profound long-run social benefits of fair use and the public domain. In all areas, one person's creativity necessarily is influenced by, and builds upon, prior creations. In principle, empirical evidence could show which of these forces is more significant, in which settings, and could thus inform the proper limits of copyright protection in the digital age. Unfortunately, this type of empirical work is unlikely to yield definitive answers, so we expect this debate to remain spirited.

Intriguingly, these competing views are battling not only in the public policy arena, as copyright law is interpreted and redefined in the face of emerging digital technologies, but in the commercial arena as well, especially in the computer software industry. The most visible example of this is the current struggle between Microsoft, promoting its ubiquitous and proprietary Windows operating system, and Linux, the open-source software operating system widely used on server computers. As fascinating as we find this particular battle,[19] it should not be seen as a test of one grand view against the other. At best, it is a test of which model (proprietary software vs. open-source software) works better in a particular market niche

[18] See Mark Bagnoli and Ted Bergstrom, "Log-Concave Probability and its Application," available at http://www.econ.ucsb.edu/~tedb/Theory/delta.pdf for more applications and theory of log concavity.

[19] For a more extended discussion of the adoption of Linux and the associated intellectual property issues, see Hal R. Varian and Carl Shapiro, "Linux Adoption in the Public Sector: An Economic Analysis," 2003.

(operating system software), with its own peculiar fact patterns (such as the substantial advantage enjoyed by Microsoft based on its installed base of Windows desktop machines).[20]

B. Patents

1. Patent Institutions

Inventors who make new, useful, and non-obvious discoveries may apply for patents that give them the legal right to prevent others from practicing their inventions during the lifetime of the patent, typically twenty years. In the U.S., patents are granted by the Patent and Trademark Office (PTO), although their validity and scope is tested in the Federal courts.[21] Some twenty years ago, Congress established a specialized appeals court to deal with patents, the Federal Circuit Court of Appeals ("CAFC").

The patent system very explicitly offers inventors a prize, in the form of exclusive rights. For significant patents, those rights confer monopoly power, and thus impose costs on consumers, most directly in the form of the higher prices resulting from monopoly power. Society also pays a price associated with this monopoly power relative to the alternative in which the invention is made and is publicly available. One type of social cost arises due to the standard inefficiency or deadweight losses associated with monopoly pricing. Other social costs result from the frictions that arise when patent holders negotiate licenses with possible complementary innovators. Because these costs are substantial, the policy of granting patents only makes economic sense (and should only be applied) for the types of inventions for which it is sufficiently likely that innovation would be substantially reduced or delayed in the absence of a patent prize to reward successful innovation.[22] This insight is reflected in the legal requirements that the invention be

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[20] It may also be an imperfect test if assertions of intellectual property (such as recently made by SCO against Linux) creep into the open-source world. Legally, open-source software is not devoid of intellectual property. Rather, intellectual property is asserted and a licensing agreement promises full and perpetual absence of exclusion or demands for money. This may in part guard against later assertions of intellectual property rights against open-source software. For more on the General Public License used by Linux, see Varian and Shapiro, op. cit.

[21] We focus here on patent institutions in the United States. However, inventors often file for patents in many countries. We do not address the issue of international harmonization of patent laws.

[22] Other systems are of course possible, such as government funding of research and development, monetary prizes for successful invention, and the academic compensation models. But these systems seem, at best, useful in limited areas: government funding is critical for basic research, and monetary prizes seem to make sense for those who

"novel" and "non-obvious." In exchange for the temporary exclusivity associated with the patent grant, the inventor must publicly disclose the workings of the invention.

2. Growing Number of Patents

As noted above, many high-tech manufacturers such as IBM, Intel, and Motorola receive hundreds if not thousands of patents each year. In some respects, this pattern is not new—industrial leaders have long relied on patents as one means of appropriating returns on their R&D and gaining competitive advantage, although research suggests that it has never been the only or even predominant means. But the ways in which patents are used has changed markedly over the past twenty years.[23]

Several robust findings emerge from this literature. First, there clearly has been a rapid increase in the overall number of patents issued, especially in the information technology sector, including in particular software patents and business method patents. Second, the propensity to patent, as measured by the number of patents per expenditures on R&D, has risen as well. In principle, these patterns could result from a surge in innovation flowing from a wealth of innovative opportunities. Perhaps the impressive recent advances in basic science and technology have led to greater opportunities for patented invention than in the past.

But there are good reasons to believe that other forces are at work as well.[24] First, creation of the Federal Circuit Court of Appeals appears to have given more power to patent holders. Second, there also appears to have been a shift in the strategic use of patents, with more firms using their patents offensively to exclude rivals and/or collect royalties, thus inducing more firms to seek patents defensively to fend off such tactics. Third, there are widespread reports that the PTO has issued a large number of "questionable" patents, especially in the information technology sector, exacerbating these problems. We discuss reform of the patent system below.

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solve specific, known problems (such as proving Fermat's Last Theorem, decoding the human genome, or sending a human to Mars). For better or worse, we are stuck with the patent system as the primary method by which most inventors receive financial rewards.

[23] For a recent overview, see Nancy Gallini, "The Economics of Patents: Lessons from Recent U.S. Patent Reform," *Journal of Economic Perspectives,* 131-154, 2002.

[24] See S. Kortum and J. Lerner, "Stronger Protection or Technological Revolution: What is Behind the Recent Surge in Patenting?" *Carnegie-Rochester Conference Series on Public Policy,* 247-304, 1998.

3. Does the Patent System Provide Suitable Incentives to Innovate?

Even when it is functioning well, does the patent system provide appropriate incentives for private firms to engage in innovative activities?

Ever since patents have been issued, debate has raged over whether the patent system was working effectively to stimulate innovation: do the property rights associated with patents serve a strong enough incentive for innovation to warrant the costs associated with the resulting monopoly power? This debate continues in full force as patents have become especially important in the information technology sector of the economy. More specifically, since the patent system provides a prize to inventors, in the form of exclusive rights, one might well ask whether that prize is too big, too small, or just right, to provide suitable incentives to inventors. Unfortunately, there is no easy or general answer to this question, despite a mountain of theoretical and empirical work devoted to the topic.

A simple, static model can help illustrate some of the tradeoffs involved. Criticism of that same model can show why the underlying question about the magnitude of rewards to patent holders is so tricky to resolve either theoretically or empirically.

Consider an invention that enables the production of a new product (or service). Assume (for now) that the patent holder sets a single price for its product. Denote the demand for this new product by $P=D(X)$, where P is the price per unit and X is the quantity demanded. The revenues are thus given by $R(X)=XD(X)$. The total gross benefits to consumers if X units are produced are given by $B(X) = \int_0^X D(X)dX$. Consumer surplus is given by S(X)=B(X)-R(X).

Let the cost to the inventor of producing the new product (once the discovery is made) be given by $C(X)$. Then the (post-discovery) profits to the patent holder are given by $\pi(X)=R(X)-C(X)$ if a quantity X is produced. Total post-discovery welfare (profits plus consumer surplus) is given by $W(X) = \pi(X)+S(X) = B(X)-C(X)$.

As usual, the profit-maximizing quantity equates marginal revenue and marginal cost. Call the optimal quantity X^*, with corresponding price $P^*=D(X^*)$, profits $\pi^*= \pi(X^*)$, and consumer surplus $S^*=S(X^*)$. Recall that consumers enjoy surplus even when buying from a monopolist,

so long as the monopolist cannot engage in perfect price discrimination. Some consumers value the product above the monopoly price, P^*, and thus enjoy surplus. The magnitude of consumer surplus depends upon the shape of the demand curve. Consumer surplus is large if there are a good number of consumers who place very high value on the new product, but still enough consumers with lower willingness-to-pay so that the profit-maximizing price is modest. Our main point, for now, is that considerable consumer surplus can stem from new products, even those (such as patented pharmaceutical drugs) supplied by a monopolist.[25]

Now we are ready to consider the incentives facing the would-be innovator. Begin with the simple case in which (A) there is only a single firm that recognizes the potential for this particular innovation, and (B) demand for this product comes only at the expense of other products that are competitively supplied, and not at the expense of other products supplied by firms with market power.

Suppose that the potential innovator can devote more resources to research in this area and thus increase the probability of successful invention. (The analysis is similar if greater R&D efforts lead to *earlier* invention.) Suppose that the probability of successful invention is $Q=F(Y)$ if the firm spends Y on R&D, where research expenditures have position but decreasing return, so $F'(Y)>0$ and $F''(Y)<0$ for all $Y>0$. Assuming, for simplicity, that the firm is risk neutral, and thus maximizes expected profits, the firm picks Y to maximize $F(Y)\pi^*-Y$. The firm's optimal level of R&D expenditures, Y^*, is given implicitly by $F'(Y^*)=1/\pi^*$. The larger are the resulting profits, π^*, the smaller is $1/\pi^*$, and hence $F'(Y^*)$, which requires a larger value of Y^*, since $F''(Y)<0$. These calculations confirm the intuitive point that the firm will invest more in R&D, the larger are the profits associated with making the invention and obtain the patent.

In this simple case, the socially optimal level of R&D investment given the patent system, Y^{**}, is larger than the profit-maximizing level of investment, Y^*. The socially optimal level of R&D investment maximizes the expected social returns, $W(Y)= F(Y)(\pi^*+S^*)-Y$. The first-order condition for Y^{**} is given by $F'(Y^{**})=1/(\pi^*+S^*)$, which is less than $1/\pi^*$, which equals $F'(Y^*)$.

[25] Consumer surplus may be reduced if the patent holder can engage in price discrimination. In the extreme case of perfect price discrimination, there is no consumer surplus during the lifetime of the patent.

Therefore, we have $F'(Y^{**})<F'(Y^{*})$, which, using $F''(Y)<0$, implies that $Y^{**}>Y^{*}$. Intuitively, the profit-maximizing firm does not account for the consumer surplus generated by its invention, S^{*}, when picking its R&D investment level. Effectively, invention generates a positive externality on consumers.

Therefore, this very simple static model suggests that the patent system provides *insufficient* incentives for inventors. This observation is strengthened once one recognizes that the patent only lasts for twenty years, so the consumer surplus resulting from the invention includes not only the consumer surplus during the first twenty years associated with the monopoly price, but a presumably higher level of consumer surplus associated with competitive prices indefinitely once the patent expires (holding aside issues of whether the patent becomes more or less commercially important over time). When one remembers that the patent holder also must disclose its invention, and other inventions may well build on this patented discovery, the benefits enjoyed by society that are not captured by the patent holder appear to be significant.

While all of these effects are real, the static model presented is too simple to form the basis for such a broad policy conclusion, for at least two important reasons that we now explain.

First and foremost, the model simply assumed that the invention at issue would never have been discovered if not for this particular inventor. This presumption was built in when we assumed in defining $W(Y)$ that the "but-for" world without this firm's invention would be no invention. A very different result would obtain if we assume, instead, that the same invention would have been made a short time later. For example, in March 1876 Alexander Graham Bell received the patent on the telephone, having filed his application two weeks earlier on the same day as Elisha Gray, an employee of Western Union, filed a patent caveat.[26] Such near-simultaneous invention is actually quite common, especially when advances in basic science open up new commercial opportunities that are recognized by many firms who then race to be the first to turn the basic discovery into a practical and useful invention suitable for patent protection. To study this properly requires a dynamic model. Roughly speaking, however, in the static model already

[26] See e.g. Gerald Brock, *The Telecommunications Industry: The Dynamics of Market Structure*, Harvard University Press, 1981, page 89.

presented, *W(Y)* would be far, far smaller. If we think of measuring all the variables in the static model as present discounted values, *W(Y)* would correspond to the flow of social benefits for the period of time until someone else would have made the same discovery. However, the social cost of awarding the patent, the deadweight loss from the patent monopoly, runs for the full twenty years in the patent lifetime.

Therefore, the rewards to the patent holder can easily far exceed his or her social contribution, if indeed the same discovery would likely have been made by another in the near future. This tendency is all the greater if each company invests in R&D not simply to maximize its own return considered in isolation (as assumed above) but in order to accelerate its discovery and thus win the patent race.[27] In practice, it is usually extremely hard for any agency in charge of issuing patents to tell whether a given discovery was a "flash of genius" that no one else would have discovered any time soon, or "in the air" and likely to have been discovered very soon by others. But at the least we should be wary of patents issued in industries with a very large number of incremental innovations driven by underlying advances in basic science and underlying, widely-known technology.

Second, we should account for the fact that patented products often are substitutes for other products that are priced well above marginal cost. Under well-known principles of "profit stealing," there can be excessive incentives for private, profit-maximizing firms to engage in commercial activities that shift business from one firm with market power to another.[28] This is due to the negative externality imposed on the firm losing the customers.[29] Once such "profit stealing" is recognized, it no longer follows that the social returns to invention exceed the private returns, even for an invention that would not have been discovered any time soon by others. Not surprisingly, there is a large literature on the economics of the patent system.

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[27] For an overview of the literature on patent races, see Jennifer Reinganum, "The Timing of Innovation: Research, Development, and Diffusion," 849-908, in *Handbook of Industrial Organization,* R. Schmalensee and R. Willig, eds., North-Holland, 1989.

[28] See for instance Gregory Mankiw and Michael Whinston, "Free Entry and Social Inefficiency," *Rand Journal of Economics* vol 17 no 1 (Spring 1986) 48-58.

[29] Some readers may wonder why "externalities" play a role here, and above when we said that a new product generates positive externalities for consumers, given that there are no "missing markets" in these models. The reason is that pecuniary externalities can give rise to real welfare effects in the presence of market power.

4. Licensing and the Diffusion of Innovations

While the patent confers upon the patent holder the exclusive right to practice his or her invention, in practice patent holders frequently issue licenses permitting others to practice their inventions. Licensing is common in some industries, including much of the information technology sector, but far less common in other industries, such as pharmaceuticals.

Licensing is important for at least two reasons. First, some patent holders can earn far greater profits by licensing their patents than by keeping their inventions to themselves. This is especially clear for a patent holder who has limited presence in the market yet has obtained a patent for technology that is valuable for many large or incumbent suppliers. Second, licensing promotes the usage and diffusion of new technologies. Happily, unlike stronger patent protection, which at best can promote innovation at the expense of diffusion and short-term monopoly power, licensing can simultaneously promote both innovation and diffusion.

Of course, the terms and conditions on which licenses are granted will greatly affect the economic impact of licensing. Under a simple license, the patent holder grants the licensee the right to use the patented invention and in return the licensee pays license fees, usually either some fixed fee or a percentage of the revenues earned on products that embody the patented inventions, or both. One or more patents may be licensed in the same transaction. Firms frequently offer package licenses, under which the royalties associated with a group of patents are less than the sum of the royalties offered for the individual constituent patents.

Increasingly, firms are entering into cross licenses. Under a cross-license, in exchange for the right to practice A's patented invention, firm B grants firm A the right to practice firm B's own patented invention. Effectively, cross license are a form of barter using patents. Cross-licenses without running royalties are especially attractive and efficient from an *ex post* competitive perspective: they permit the diffusion and use of patented technology without elevating the marginal costs of either party. Monetary payments, either one-way or two-way, may also be included in cross licenses. The use and prevalence of cross-licensing varies greatly across industries.

In the semiconductor industry, many of the larger firms enter into cross licenses involving a number of patents, or entire patent portfolios. These broad cross-licensing agreements can cover

existing patents, current patent applications, and even future patents for which applications have not yet been filed. When two large semiconductor firms enter into a broad, forward-looking cross license, they have effectively chosen to replace the patent thicket that would otherwise result from the operation of the patent system with a largely "patent-free zone," at least vis-à-vis each other.[30] Perhaps this judgment suggests that the "default" patent regime has become dysfunctional in the semiconductor industry. Manufacturers in that industry seem to despise those firms who accumulate (or acquire) intellectual property without themselves being producers: a manufacturer cannot use its own patents "defensively" against such firms. Naturally, this raises the question of whether non-producing firms that obtain patents are being rewarded in ways that are excessive given their actual contributions. If such a firm obtains a patent for a valid innovation that would not have taken place without that firm's innovative effort, the mere fact that a non-producing firm lacks interest in cross-licensing is no reason why that firm should not be able to assert its patent rights. However, one might view the widespread dissatisfaction with such non-producing firms as signaling that (in the industry view) many of the patents issued are "bad," but that, as long as all patent-holders are also producers, the industry has a decent work-around.

C. Trade Secrets

Trade secrets are useful information that individuals or companies possess and do not share widely with others. Trade secrets are a form of intellectual property and receive legal protections, most importantly to prevent *theft* of trade secrets. There is no fixed lifetime to the protection afforded to trade secrets.

However, unlike copyright and patents, trade secrets lose protection once they leak out into the public domain through reverse engineering or disclosure by the owner of the trade secret. Therefore, owners of trade secrets must be vigilant about protecting their secrets and preventing the unauthorized use of those secrets. Lawsuits involving alleged theft of trade secrets are common when employees who have learned valuable trade secrets depart and go to work for

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[30] One concern is that incumbents with large patent portfolios can thus declare a type of "patent truce" while still keeping out would-be entrants who lack a sufficient portfolio to join the "club." We consider this line of reasoning interesting but incomplete.

rival firms. Trade secrets can be licensed; of course, such licenses must contain provisions to make sure that the licensee does not transmit the secret to third parties without the permission of its owner.

Trade secret protection is weak in that the owner of a trade secret cannot prevent others from using the secret know-how if they discover it independently. Therefore, a company who develops new technology often faces a complex decision whether to keep the new technology secret or file for a patent. If the company elects the trade secret route and prevents the secret know-how from entering the public domain, the law will help it prevent others from stealing its secrets. However, the secret might be rediscovered independently and either enter the public domain (for all to use) or, worse, be patented by the later discoverer, in which case the original innovator could even be forced to stop using the technology *itself* or have to buy a license from the patent holder.[31] Alternatively, the original discoverer can file for a patent on its new technology, and if it gets one, will get the right to prevent others from using it. Of course, the *quid pro quo* for obtaining a patent is the disclosure of the invention to the public, making it more likely that other firms will attempt to use the patented invention, perhaps invent around it, and even built on it to obtain their own patents. Plus, in some cases, the patent may be hard to enforce. For example, for a patent involving process technology, the patent holder may find it very difficult to determine which other firms are in fact using its patented processes. Furthermore, the patent will only last for 20 years, while trade secrets can be kept indefinitely.

Having discussed intellectual property protection in general, and identified some broad issues, we turn now to discussing how information technology supports the three general strategies of differentiation, lock-in and proprietary standards.

3. Differentiation of Products and Prices

Professor Varian illustrates how firms use information technology to engage in price discrimination. As he notes, price discrimination may be an especially attractive tactic in

[31] The original inventor cannot prevent another from patenting the discovery by arguing that its usage constituted "prior art," since discoveries that are concealed do not qualify as "prior art" under patent law.

information markets, because the high fixed ("first-copy") costs and low marginal costs for information goods imply that entry will not normally take place to the point where competition forces firms to price near marginal cost to all customers. As usual, price discrimination requires some degree of market power, typically based on offering a differentiated product, and the ability to prevent arbitrage. For the software and content industries, copyright protection is critical to product differentiation (by preventing unauthorized copying) and often important as well for the prevention of arbitrage (through restrictions on sublicensing or transfer of the license, included in the original licensing of the copyrighted material, that prevent "resale").

An interesting illustration is how the music industry has responded to on-line distribution via the Internet. One might hope that the industry would welcome and take advantage of a new, low-cost distribution medium. If piracy can be controlled, either through legal means or technological means including "digital rights management," on-line music distribution should be a boon both artists and the music labels that sign up and promote artists and distribute their music (but not for traditional music retailers unless they can somehow transfer their brand names or other assets to online distribution). Distribution costs could fall dramatically. After all, several dollars of the $15 retail price for a typical music CD goes to the retailer. If a music label could save this distribution cost, and the cost of producing physical disks, it could either lower its prices by several dollars per CD or enjoy a bigger profit margin (or some combination).

The music industry is now pursuing on-line distribution. Sony and Universal initially formed a joint venture called Pressplay, while Warner, EMI, and Bertelsmann promoted an alternative service known as MusicNet. But users complained that these services imposed so many restrictions on the use of the downloaded music that they were not very attractive. For example, MusicNet initially only allowed streaming or listening for a limited time. More recently, legal music download services, most notably Apple's iTunes, have become more attractive and more widely used.

But this embracing of on-line distribution has been slow; the industry first saw it as a threat, much as the movie industry initially did with the VCR. While a low-cost complement to the industry is normally beneficial in the long run, in the short run it threatened to disrupt existing pricing models and, worse, to facilitate piracy. Thus the peer-to-peer network Napster became a

familiar name, although the vast majority of songs shared on Napster involved piracy. Eventually, the music companies were able to shut down Napster based on copyright infringement.[32] Whether other peer-to-peer file sharing services that are more decentralized, such as Grokster, can survive the legal attack of the music industry remains to be seen.[33]

On-line music illustrates the differentiation, or versioning, of products and prices. Firms can and do offer a variety of terms and conditions under which a song can be used: Does the customer purchase the right to play the song once, or multiple times but only for a day or a week? Can the customer transfer the song to a mobile device or burn the song on a CD? Can the customer make multiple copies for use on different devices? Clearly, the licensed rights associated with even a single song can be sliced and diced in a multitude of ways. More broadly, music can be sold as concerts (from which ancillary or complementary revenues such as parking and T-shirts may be very important), and/or as recordings, with complex possibilities of substitution and complementarity (one may be more rather than less likely to buy a CD if one attends a concert, or if one's friend did so).

Much the same is true of the movie industry. Originally movies were distributed to theatres and audiences paid the theatre for a viewing. Later, studios realized they could sell rights to televise their movies (and the broadcasters could collect money through advertising). VCRs were originally seen as threatening this model, by enabling consumers to watch the movie-with-ads later (time-shifting) and possibly skipping over (or being more willing to leave the room during) the advertisements. Universal Studios sued Sony (the producer of the Betamax VCR) for facilitating consumers' copyright infringement, but the Supreme Court held (see the citation given above) that since Betamax had substantial legitimate uses, Sony was not liable. Although this may have left Betamax *users* liable in principle for copyright infringement, the industry had

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[32] See A&M Records Inc. v. Napster Inc., 239 F.3d 1004 (Ninth Circuit, 2001). Interestingly, Roxio purchased Pressplay in May 2003 and re-launched this service under the Napster name.

[33] As of this writing, the Ninth Circuit is considering the Grokster case, Metro-Goldwyn-Mayer Studios, Inc., et. al. v. Grokster Ltd. Central to this case is the interpretation of the Supreme Court's opinion in the landmark "Sony Betamax" case, Sony Corporation of America vs. Universal City Studios, Inc., 464 U.S. 417 (1984), which protected technologies with substantial non-infringing uses from secondary liability from copyright infringement, even if those technologies were also used in ways that infringed on copyrights. For an analysis of the Grokster case, see, for

little chance of preventing home recording and eventually figured out a way to embrace rather than fight the technology. Now, both movie studios and TV networks sell—and rent—tapes and DVDs of their programming. With the advent of digital cable, video-on-demand, whereby customers pay for a single viewing of a movie or other programming, is becoming more and more popular. As broadband connections become more widespread and computers become yet more powerful, we expect this model to spread to movies delivered over the Internet rather than via the traditional cable television technical and business model.[34]

Price discrimination is attractive to the music companies for another reason as well having to do with the strength of their copyright protection: the elasticity of demand for on-line music is likely to be higher than the elasticity of demand for CDs or other forms of music, because of the threat of illegal downloads. After all, the main alternative to *legally* downloading a song for many people may be to *illegally* download the same song. Thus, for many customers, especially those who use computers heavily and have fast online connections, illegally downloaded copies are a close substitute for legal copies.

The music industry has tried to make illegal downloads a less attractive substitute by public-relations attempts to make people feel guilty about stealing copyrighted music and by suing individuals who illegally download large numbers of songs. The industry has hesitantly begun to authorize legal downloads, through Apple's iTunes service (http://www.apple.com/itunes) and others, which offer large libraries of songs, typically at 99 cents each. Unlike earlier legal services, iTunes does not impose sharp restrictions on the use of the downloaded songs.

Online distribution is less advanced in the movie industry, but the same dynamic is likely to play out over time. Downloading huge movie files will become more practical as broadband Internet access becomes more widespread, as computers have larger and larger memory to hold these movies, and as computers become networked with (or even become) televisions and other home entertainment equipment. Some of the major movie studios (MGM, Paramount, Sony, Universal

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example, the Brief Amici Curiae of 40 Intellectual Property and Technology Law Professors Supporting Affirmance, available at http://www.sims.berkeley.edu/~pam/papers.html.

and Warner), keen not to let an illegal service like Napster take root first, have already moved ahead with their own legal service, Movielink (www.movielink.com).

Let us now ask what the movie and music industries would do if copyright protection were far weaker, so that a buyer of a CD or DVD could, fairly easily, give copies to friends or even sell them cheaply to strangers. One possibility is that studios would just scale back their operations: fewer artists or movies would be profitable. Another possibility is that the industry would pursue technological copy protection, for instance selling disks that need a one-time complementary digital "key" to function, especially if a strong DRM system could prevent users from copying the protected work in a less secure form. A third possibility would be reverting to "public performances" (presumably with camcorders banned from the theatres) as the major revenue source. A common theme is that one might expect those who control content to hold the content more closely if they become less able to let it out without losing control over it completely.

A very different alternative is to put the content out there without trying to charge much for it, and to earn one's revenues through the sales of complements. For instance, a firm might offer content (software) for free, but ensure that it can only be played on its proprietary hardware (and charge a markup on the latter). Of course, something would have to prevent copying of the hardware, but at least hardware is not subject to costless reproduction and distribution using digital technology. Such a strategy might seem to require consumers to own half a dozen separate CD players, clearly an unacceptable alternative, but this could be avoided by using a generic CD player along with suitable "keys" that would let that player play records from the various labels, rather as the authorization information is encoded in the SIM in a GSM phone. If the key were temporary, this would be like a subscription TV service. Hardware manufacturers might even bundle multiple such keys, in the limit effectively funding the software industry by something close to a tax on hardware. In Britain, the BBC is funded by a (government-enforced) tax on owning a TV set. Clearly, the legal and technical aspects of DRM systems become quite

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[34] In the US, most residential broadband Internet access is via cable modems, and it is an open question how far cable companies will try to exert control over this trend as it threatens their traditional business model but opens up new possibilities.

important in these scenarios.[35] An alternative complements strategy is to bundle the music, or video content, with advertisements. This is already happening in television shows, where "product placement" is becoming more important.

4. Switching Costs and Lock-In

Intellectual property rights greatly influence the switching costs associated information technology such as computer hardware and software. A leading example is Microsoft Office. In addition to the user interfaces associated with Microsoft Word, Excel, and PowerPoint, with which millions of users have become familiar, these software programs involve proprietary file formats that have trade secret and copyright protection. File formats are an important aspect of switching costs: a major obstacle facing other productivity programs is the difficulty they have achieving full compatibility when importing and exporting files from and to Microsoft Office. For example, Sun's StarOffice has had trouble offering good enough compatibility to take significant sales away from Microsoft Office.

To illustrate how property rights can affect switching costs, consider "number portability." Only in late 2003 did the Federal Communications Commission finally require wireless phone companies to let customers keep their phone numbers when switching carriers; the analogous requirement for "ordinary" phones was part of the 1996 Telecommunications Act, and its implementation was made a pre-condition for Bell companies to provide long-distance service in-region. Although theory suggests that the net effect of portability could be to reduce or increase prices (because competition for new customers is so intense if those customers will later experience high switching costs), most informed commentators seem confident that it will increase competition and cut prices.[36] There is no immediate prospect for "e-mail address portability," so that most people change their email address when they change ISP (or employer). Similar issues arise when customers want to take "their" data to a new provider, as when a

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[35] For one view of DRM, see Pamela Samuelson, "DRM {and, or, vs.} the Law," *Communications of the ACM,* April 2003, available at http://www.sims.berkeley.edu/~pam/papers.html.

[36] See Brian Viard, "Do Switching Costs Make Markets More or Less Competitive?", Graduate School of Business, Stanford University, 2004.

patient wants to take medical or dental records to a new doctor or dentist or even a new on-line supplier of groceries or books.

While many economists often think of markets with switching costs as involving repeated purchases of the same good, an equally important pattern is the sale of a "primary" good in a "foremarket" followed by purchases of a complementary "secondary" product in an "aftermarket." In these situations, there can be switching costs if the seller of the primary good has an advantage in selling the complement. A classic example involves the sale of a piece of durable equipment, such as a photocopier, followed by aftermarket sales of parts and service for that equipment. Clearly, the equipment manufacturer has an advantage in selling spare parts for its own machine, especially if such parts are patented or manufactured subject to significant economies of scale. Another example involves the licensing of complex business software, such as database software or transaction processing software, followed by annual upgrades and support for that software. Again, the initial vendor is very likely to have a significant advantage over third party vendors in providing both upgrades and support for its software.[37] In some cases, the "aftermarket" occurs right after the foremarket transaction. Familiar examples include telephone service from a hotel room or even food at a sporting event. Casual empiricism indicates that the prices of these complementary goods and services are well above the levels that prevail when customers face more instantaneous options.

These "secondary markets" have been controversial. The *Kodak* antitrust case received widespread attention because it had been remanded back from the Supreme Court (which had ruled that competition faced by Kodak from Xerox in the foremarket did not *necessarily* imply that Kodak lacked market power in the aftermarkets for Kodak parts and service) and because Kodak ultimately was required by the Ninth Circuit to sell its patented parts to third-party service organizations who sought to service Kodak equipment.[38] But the *Kodak* case appears to be an anomaly in imposing a duty to deal on a patent holder. Indeed, in a more recent case involving

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[37] As one of us has emphasized in previous writings, in many cases customers purchase such products based on the total cost of ownership, and effective competition takes place in the foremarket, where prices may be discounted in recognition that margins will be earned in the aftermarket.

[38] Image Technical Services vs. Eastman Kodak Company, 125 F.3rd 1195 (Ninth Circuit, 1997). Shapiro served as an expert witness for Kodak in this case.

Xerox, the Federal Circuit came to precisely the opposite conclusion.[39] A comparison of the two cases is peculiar, in that very similar practices were at issue, involving the same basic products (photocopiers), and Xerox had a far stronger position in the photocopier market, but the duty to deal was only imposed upon Kodak. One explanation, albeit not a very satisfying one, is that Xerox stressed its patent claims more strongly and earlier than did Kodak, so that the Xerox case was heard on appeal in the Federal Circuit, which arguably is more deferential to the rights of patent holders than is the Ninth Circuit. Very recently, the Supreme Court has made it clear that even monopolists will not generally be faced with a duty to help out their competitors,[40] although of course this does not mean that owners of intellectual property have a "free pass" against antitrust law.[41] In a separate intellectual property case, Lexmark (which produces printers) sued Static Control Components for violations of intellectual property when SSC reverse-engineered Lexmark's printer-cartridge interface, which Lexmark had made proprietary presumably in order to be able to mark up its aftermarket cartridges.[42]

5. Standards and Patents

Patent rights can be central as firms negotiate compatibility and interface standards. Examples include the various standards by which modems communicate, the DVD read and write standards, and the MPEG standard for coding audio-visual information in a compressed digital format. As Professor Varian notes, many standard-setting organizations require participants to disclose all relevant intellectual property rights and agree to license any essential patents on "fair, reasonable, and non-discriminatory" terms.[43] Unfortunately, these rules have regularly led

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[39] Independent Service Organizations Antitrust Litigation, 203 F.3rd 1322 (Federal Circuit, 2000).

[40] Verizon Communications vs. Law Offices of Curtis V. Trinko, Decided January 13, 2004.

[41] Thus Microsoft argued, on appeal, that "if intellectual property rights have been lawfully acquired," then "their subsequent exercise cannot give rise to antitrust liability." The court dismissed this as "no more correct than the proposition that use of one's personal property, such as a baseball bat, cannot give rise to tort liability."

[42] Lexmark International v. Static Control Components, Inc., Civil Action 02-571-KSF.

[43] For an extensive discussion of how different standard-setting organizations treat intellectual property rights, see Mark Lemley, "Intellectual Property Rights and Standard-Setting Organization," 90 California Law Review 1889 (2002), available at www.ssrn.com.

to disputes over the extent of the disclosure obligation, the scope of the licensing commitment, and what constitute "fair and reasonable" licensing terms.

The essence of the problem is that the power enjoyed by a patent holder whose technology is embodied in a standard can be far greater after the standard is widely adopted than at the earlier point in time when various alternative specifications were under consideration for the standard, some of which did not rely on the patented technology. If the participants in the standard-setting organization are aware of the relevant patent(s) early on, they can pick an alternative specification that does not infringe on the patent or they can negotiate acceptable licensing terms with the patent holder(s), perhaps even a royalty-free license. Once a standard is adopted that requires use of the patent, however, the bargaining power shifts, perhaps markedly, towards the patent holder. In other words, hold-up can develop if an industry adopts a technology as a standard and that technology later is found to infringe on a single firm's patent. The resulting *ex post* market power of the patent holder can be very substantial, especially if participants are locked in to the chosen standard through network effects as well as through ordinary sunk costs. The result is that the patent holder may be able to extract significantly more than the "true" or underlying value of its intellectual property, which is normally best measured by adopters' willingness to pay for it when they know their alternatives and have not yet made investments specific to that technology.

This problem has led to a number of disputes, several of which led to lawsuits.[44] An example is the FTC's complaint against Rambus.[45] According to the FTC, Rambus concealed from a standards organization, JEDEC, its pending patent claims for dynamic random access memory (DRAM), which it was meanwhile amending based on information from JEDEC meetings. The result was that JEDEC memory standards (allegedly) infringed on Rambus' subsequently issued patents. This is not the first case with allegations of strategic hold-up. For example, Wang sued

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[44] Both authors have served as consultants to the parties in some of these matters.

[45] In the Matter of Rambus, Inc., FTC Docket No. 9302. As of this writing, the FTC Administrative Law Judge had just issued an opinion dismissing the FTC's complaint against Rambus in this matter. See http://www.ftc.gov/os/adjpro/d9302/040223initialdecision.pdf. This decision is expected to be appealed to the Commission. A related private case was decided by the Federal Circuit in favor of Rambus. See *Rambus Inc. v. Infineon Technologies*, decided January 29, 2003.

Mitsubishi for infringing patents on a memory module design that Wang had encouraged JEDEC and the industry to adopt without disclosing its pending patents; the FTC later settled a somewhat similar matter with Dell in connection with the VESA bus. Rockwell and Motorola earlier had a dispute over Motorola's patents involving modem standards. These cases share the feature that a patent-holder's conduct allegedly created or worsened information and negotiation problems, exacerbating holdup.

We do not mean to suggest that patents always present problems in the context of standards. On the contrary, there are many examples where participants have agreed to contribute their patents on a royalty-free or low-royalty basis to a specification that becomes a new, and successful standard. A good example of this happy fact pattern is that of the Universal Serial Bus (USB), promoted by Intel.[46] The USB licensing terms require that companies making USB-compliant devices agree not to assert any patents they may have that are essential to compliance with the USB standard against others for manufacturing their own USB-compliant devices. Because of its strong position in a complement (microprocessors), Intel has incentives to make USB a successful, widely used product, suggesting that Intel judges that this weakening of intellectual property will improve the product's prospects. To be sure, Intel could also have less salutary incentives,[47] but we note that it did not succumb to the temptation (if any) to make USB unavailable on Apple or AMD-based machines.

6. Do We Need to Reform the Patent System?

More and more observers are calling for reform to the U.S. patent system. The fundamental problem identified by these observers is that of patent quality: too many "bad" patents are issued by the Patent and Trademark Office (PTO), i.e., patents are granted to companies or individual who have not made genuine inventions, or patents are granted with overly broad claims. According to this view, the PTO has failed to understand or appreciate "prior art" in many cases

[46] Shapiro served as an expert witness for Intel in one case involving the USB specification.

[47] On complementors' incentives, see e.g. Joseph Farrell and Philip J. Weiser, "Modularity, Vertical Integration, and Open Access Policies: Towards a Convergence of Antitrust and Regulation in the Internet Age," *Harvard Journal of Law and Technology*, vol. 17 no. 1 (Fall 2003).

and has awarded patents for inventions that did not in fact met the novelty and non-obviousness requirements of patent law. Such "bad" patents harm competition and innovation by imposing an unnecessary, unjustified, and costly burden on those companies or industries that are forced to either invent around these patents, pay royalties, or engage in costly and risky litigation.

Critics see these problems as especially severe in industries in which: (1) a large number of patents are being issued; (2) innovation is cumulative with a steady stream of incremental improvements, many of which should not in fact meet the non-obviousness requirement; (3) the Patent and Trademark Office has a relatively poor understanding of the technical literature and the underlying technology, and thus has frequently failed to take proper note of prior art; (4) a single product may potentially infringe on many patents, so products many be forced to pay royalties to multiple patent holders, a situation known as "royalty stacking;" and (5) manufacturers make sunk investments to bring products to market and may be held up by patents issued after these investments have been made. The semiconductor and software industries are usually thought to meet several of these criteria, and thus be most harmed by "bad patents."[48]

A recent and influential report by the Federal Trade Commission, "To Promote Innovation: The Proper Balance of Competition and Patent Law and Policy," October 2003, available at www.ftc.gov, contains several important proposals for reform.[49] The FTC Report finds (p. 5) that "questionable patents are a significant competitive concern and can harm innovation." As the term is used in the FTC report (p. 5), "A poor quality or questionable patent is one that is likely invalid or contains claims that are likely overly broad." Several key FTC Recommendations are designed to reduce harm to competition and innovation associated with questionable patents.

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[48] See, for example, Robert Merges, "As Many as Six Impossible Patents Before Breakfast: Property Rights for Business Concepts and Patent System Reform," *Berkeley Technology Law Journal,* vol. 14, no. 2, pp. 577-615; Carl Shapiro "Navigating the Patent Thicket," in *Innovation Policy and the Economy*, Adam Jaffe, Joshua Lerner, and Scott Stern, eds., National Bureau of Economics, 2001, available at http://faculty.haas.berkeley.edu/shapiro; Mark Lemley, "Rational Ignorance at the Patent Office," 95 Northwestern University Law Review 1495 (2001), available at http://repositories.cdlib.org/blewp/19; and Wesley M. Cohen and Stephen A. Merrill, Editors, Committee on Intellectual Property Rights in the Knowledge-Based Economy, National Research Council.

[49] As of March 2004, The National Research Council was expected soon to release its own report evaluating the patent system and suggesting reforms: "A Patent System for the 21st Century," Board on Science, Technology and

According to the FTC, one reason too many questionable patents are issued is that existing means of challenging (issued or prospective) patents are inadequate. Third parties cannot challenge issued patents unless the patent owner has threatened the potential challenger with patent infringement litigation; and the patent enjoys a strong presumption of validity in any such court challenge. Moreover, if a challenger's rivals also would gain from the overturning of a "bad" patent, the incentives for one firm to challenge may be quite weak. The FTC's Recommendation #1 calls for legislation to create a new administrative procedure for post-grant review of and opposition to patents. The FTC's Recommendation #2 calls for legislation to specify that challenges to the validity of a patent are to be determined based on a "preponderance of the evidence" rather than the current standard, "clear and convincing evidence." This change seems to make sense given that the PTO issues many patents based on a rather quick review and with incomplete understanding of the underlying technology or prior art. The FTC has additional recommendations to improve patent quality. Recommendation #3 seeks to tighten the legal standard used to evaluate whether a patent is "obvious." Recommendation #4 seeks additional funding for the PTO.

We also note here FTC Recommendation #7, which calls for legislation requiring the publication of all patent applications 18 months after filing. Until recently, patents were published only when issued. This created significant problems with opportunism and lock-in. As the FTC explains, "During the time that would pass between the filing of a patent applications and the issuance of a patent, an applicant's competitors could have invested substantially in designing and developing a product and bringing it to market, only to learn, once the patent finally issued, that it was infringing a rival's patent and owed significant royalties. This scenario disrupts business planning and can reduce incentives to innovate and discourage competition." We agree, adding that this scenario can harm innovation and competition even if the patent holder and the firm developing and bringing the new product to market are not rivals.

Such problems are significantly reduced now that most patent applications are published 18 months after filing; the exception is applications that are only filed in the U.S. The FTC would

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Economic Policy, National Research Council. Many critics of the current patent system are hopeful that these two reports will help galvanize support for legislative changes in the patent system.

further reduce the problem by removing the exception and requiring publication after 18 months of patents only filed in the U.S.

7. Summary and Conclusions

Intellectual property—copyrights, copyrights, patents, and trade secrets—promises to play an increasingly important role in the economy of the 21st century as information and information technology comprise a greater and greater share of economic activity. We have explained here some of the key ways in which intellectual property rights are granted and used in competitive strategy. Not surprisingly, copyright law and patent law are under pressure to evolve as information technology advances so rapidly.

Copyright law is critical in the information content industries, including publishing, music, movies, and computer software. The Courts are currently working through the proper interpretation and role of copyright law and policy in the digital age. New technologies, many fitting under the rubric of "Digital Rights Management," can be used by rights holders to restrict what would otherwise be the fair use of copyright works. Few expect rapid resolution of the battle between those who see the Internet as a great intellectual commons where "information wants to be free" and those who see the Internet as a giant illegal machine for unauthorized copying of copyrights works.

Likewise, patent law and policy are under pressure as the number of patents grows rapidly in the information technology sector of the economy. Many observers are deeply concerned that the patent system is out of balance, with the Patent and Trademark Office issuing many "questionable" patents and thereby harming competition and innovation. Here, the battle between those who benefit from the current system, with its arguably lax standards for the issuance of patents, and those who bear the costs of those patents, also is heating up rather than winding down. In the near future, there is a real prospect that the U.S. patent system will be reformed to reduce the number of "questionable" patents, perhaps along the lines suggested in the Federal Trade Commission's recent report.