Information Technology & Competitive Advantage

The Patent Explosion

March, 2005

by Anthony Williams

New Paradigm

Themes of the Open Networked Enterprise addressed in this report:

1. World View
2. Corporate Boundaries
3. Value Innovation
4. ▶ **Intellectual Property**
5. Modus Operandi
6. Business Processes
7. Knowledge and Human Capital
8. Information Liquidity
9. Relationships
10. Technology

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Specifically the program examines how a new business model—The Open Networked Enterprise—is emerging as the foundation of competitiveness, growth and sustained success.

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The Patent Explosion

The Idea In Brief

Over three decades of rapid invention in information technology has produced the most dynamic platform for global business innovation and competition the world has ever known. Progress was bolstered by a culture of reciprocal sharing of ideas and technology mixed with a prudent level of intellectual property protection. Today, the delicate balance between proprietary and open systems is at risk of unravelling. Innovation and commercialization are being undermined by serious excesses in the intellectual property system, including:

- A flood of questionable software and business method patents that give holders unwarranted legal and economic leverage
- An accumulation of dense thickets of overlapping property rights that encumber firms with excessive transaction costs and royalty fees
- A rising torrent of patent litigation abetted by the willingness of the courts to impose injunctions and patent infringement awards
- The emergence of "patent trolls" that play the system like a lottery—patenting things that other companies will unintentionally infringe, waiting for those companies to bring products to market, and using the threat of an injunction to extract hefty fees
- Pervasive uncertainty about legal rights, both in terms of the ability to enforce one's own patents and the ability to avoid infringement claims by others, which, in turn, piles new risk on top of already risky R&D investments

The effect is that the intellectual property system is actually eroding the foundations of innovation and perverting many of the virtues of patent protection. At the very least, these developments cause firms to waste management attention and resources. At worst they stifle innovative energies in a shroud of complex legal procedures.

Claims of a looming crisis are overblown. Nevertheless, an overburdened intellectual property system is struggling to cope with rapid and cumulative invention in new and increasingly complex domains that, in some cases, did not even exist a decade ago. Just as other public institutions need periodic reform as technology and the economy changes, so to does the patent system.

The stakes have never been higher. More economic activity is dedicated to knowledge production; more of the market value of firms depends on intangibles like intellectual property; and more competitive levers are about innovation and time to market. If left unresolved, these problems will undermine competitiveness.

Fortunately, smart firms are not helpless in the face of the sclerotic pace of legal reform. The answers to these problems turn on the strategies we adopt to manage intellectual property in Open Networked Enterprises. From IP marketplaces, to patent pools, to open innovation networks and concepts like the Creative Commons, leading firms and organizations are pioneering a range of models that blend open and closed innovation strategies and public and private intellectual property regimes into powerful new combinations. The promise is that Open Networked Enterprises that adopt these strategies can leverage value from their IP while also ensuring robust technological progress and a sustainable supply of innovation.

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1.0 The Patent Explosion

In this study we take a close empirical look at the explosive growth of patents in high-tech industries. The patent data is interesting for several reasons. Patents are a leading, albeit imperfect, indicator of industrial R&D output. Analysis of such data over time gives us information about the inventive performance of firms and industries, the development of technologies and industries and the strategies that firms deploy to attain competitive advantage from their intellectual capital and inventive output.

Empirically, the picture is unambiguous. The mid-1980s mark the beginning of tremendous growth in the rate at which patents are issued on new inventions (see section 1.3). In the United States, patent applications to the USPTO have tripled since 1980, while the number of patents granted has doubled. The total volume of patents issued in Europe and Japan may be less, but the European and Japanese patent offices have experienced similar levels of patent growth. More recently, emerging markets such as Brazil, China and India have also exhibited large annual increases in patent grants, although 60–65% of this growth is due to increasing numbers of applications from U.S., European and Japanese firms.[1]

The causes and consequences of the patent explosion are less clear. Most scholarship on the issue proceeds from the assumption that legal and political institutions have a deterministic effect on business behavior. One widely accepted argument is that patent reforms in the 1980s strengthened intellectual property rights, and in turn this provided firms with incentives to patent a greater proportion of their inventions. Institutional changes, in other words, caused firms to increase their patenting activity and to deploy their patents more strategically. This "institutional change" hypothesis is bolstered by the fact that the patent explosion was preceded by a series of substantial patent reforms.

A strong argument could also be made, however, that legal and political reforms in the 1980s were largely an attempt to accommodate changes in the economy and business behavior that were already well underway. Recall that rapid and profound shifts in technology, the economy, and business strategy and organization, were also unfolding in the 1970s and 1980s. These changes contributed to the growing inventiveness of high-tech industries and to increasing the relative importance of intellectual property as a competitive asset. Hence, they could equally have caused firms to a) invest more in R&D in order to generate more IP, b) attempt to harvest more patents from the R&D programs and c) demand stronger, broader and more cost-effective protection for new inventions. These factors could explain why we see an increase in patent applications and why patent officials have instigated reforms to catch-up with demand. This "institutional accommodation" hypothesis also fits the facts, but leads to a very different set of conclusions about the direction of causation.

That the two rival hypotheses are observationally equivalent—i.e., both result in an increase in the rate of patenting by firms—means that it is difficult to uncover the exact causes of the patent explosion. On one hand, the strength and breadth of patent protection plays a role in determining the potential pay-offs from innovation, and therefore has an effect on the types of innovations that will be profitable for firms to pursue. If patents are less costly to obtain and afford more protection, it seems logical that more firms might seek to obtain them. As the data reveals, the extension of patent protection to emerging technological fields such as software and biotechnology naturally opened the door to a flood of patent applications from firms in related industries.

On the other hand, we think some observers attribute too much causal power to patent reforms. We prefer to focus on the role of R&D-intensive firms in bringing about changes in the strategic context that make patents more valuable. By examining how firms leverage their intellectual property in different industries and exploring the relationship between patent strategies and competitive strategies, we get a better sense of how the patent explosion maps onto broader strategic and structural shifts in high-tech industries.

To further establish the relationship between intellectual property rights, competitive strategy and the propensity to patent in different industries, we undertake three types of analyses.

First, we survey the economic and political forces driving the rate of patent growth. After looking at changes in the broader economic environment, we examine reforms in the U.S. patent system. Taken together, we can see how patenting was encouraged and why the patent growth rate soared after 1984. This gives us a foundation on which to think about how an impending period of institutional accommodation and change, driven by the next wave of information technologies, will generate new challenges for firms seeking to reap competitive advantages from their intellectual property.

Second, the data reveals that the patent explosion is not uniformly distributed across industries. Rather, it is concentrated in IT and the electronics industry and, to a lesser degree, in the biotechnology and pharmaceuticals industries. The surprising finding is that, on average, IT industry companies obtain up to four times as many patents per million R&D dollars than firms in comparable industries, including highly inventive biotechnology firms. This conflicts with another finding that while patents have historically been very important in the life sciences, they had not previously been considered an important mechanism for appropriating returns from innovation in the IT industry. This finding leads us to ask what might have changed in the nature of the IT industry to make patents comparatively more important there than in other innovative industries.

Third, we take a close look at how firms gain proprietary advantage from R&D in different industries. We question whether IT firms actually deploy their patents in a strategic sense and whether their deployment accords with the conventional uses presumed by economic theory and public policy. A number of studies indicate that IT industry patents have more strategic value as a defensive mechanism against litigation than they do as an incentive for innovation. The existing pattern of use suggests the IT industry may actually be collectively better off if patents (or litigation) were pursued less aggressively, or alternatively, if mechanisms to mitigate adverse effects arising from the defensive use of patents were more widely adopted. This becomes an important theme later in the paper.

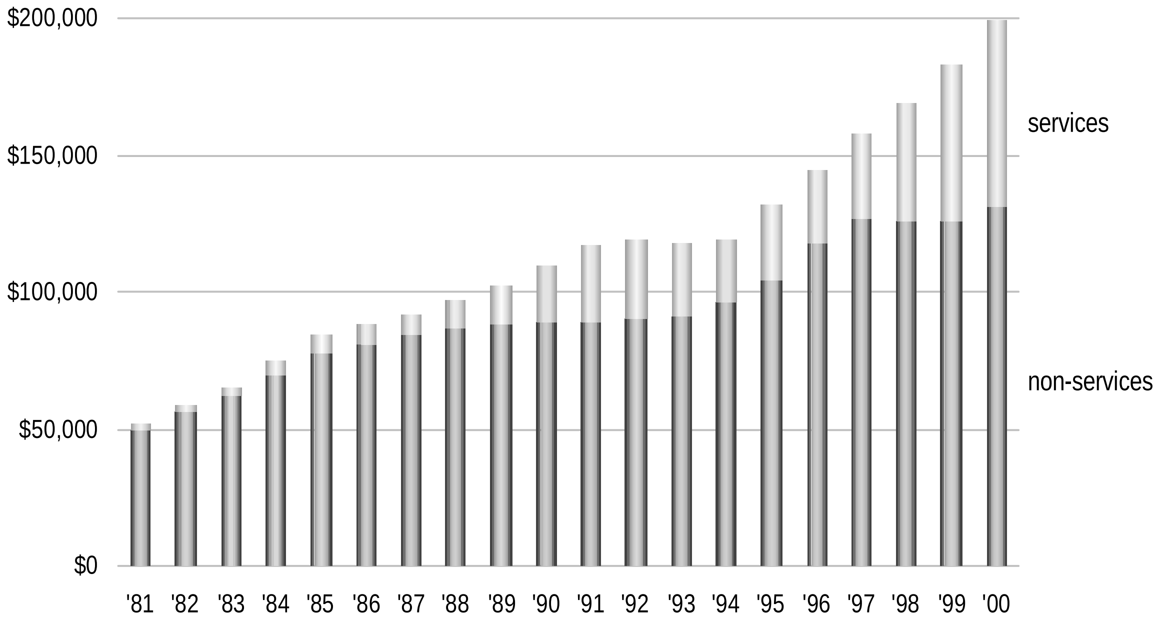
1.1 Driving forces in intellectual property rights protection

In this section we examine the hypothesis that the growing importance of intellectual property rights is caused by changes in the economic, technological and business context. We assert that the patent explosion can largely be attributed to the economic and technological forces that make intellectual property more valuable as a source of competitive advantage. The growing strategic value of intellectual property, in turn, is driving firms to a) attempt to increase the productivity of their R&D activities, b) more actively manage intellectual capital and c) demand more robust protection for their inventions. We think seven forces are central to this trend.

1.1.1 Increasingly knowledge-centric economy

The most central force is the shift to an increasingly knowledge-centric economy. As scholars such as Paul David and Moses Abramovitz point out, the shift is more of a sea change than a sharp discontinuity. Indeed, knowledge, and its application to new products, processes and organizations, has always been the engine of progress in capitalist economies. But, the contemporary era is distinguished from previous eras by the accelerating speed at which knowledge is created, accumulated and depreciated, and the unprecedented share of economic activity dedicated to the creation and application of intellectual capital.[2] Recognizing the potential value of their intellectual capital, firms in knowledge and R&D intensive industries are exploring new ways to leverage their portfolio of intellectual property. These strategies range from internal patenting procedures to external technology licensing and acquisition programs. Meanwhile, most of the advanced industrial nations want to strengthen and harmonize the international system of intellectual property rights.

Figure 1a Total business expenditure on R&D, 1981–2000 (million current USD)



1.1.2 Innovation becomes the dominant competitive differentiator

For high-tech industries in particular, innovation has become the dominant competitive differentiator. As a partial measure of the growing importance of innovation, we see that total business expenditure on R&D in the United States quadrupled from $50 billion to $200 billion between 1981 and 2000. Much of this growth is attributed to high-tech manufacturing and knowledge-intensive services sectors, particularly the IT and pharmaceuticals industries—the same sectors where we observe the most rapid increases in patenting. Indeed, the rapid pace of discovery and invention in industries such as biotechnology, biomedicine, electronics and IT is unparalleled in history, and a substantial contributor to the patent explosion.

1.1.3 Rising global competition

The economic climate since the 1980s is characterized by rising global competition. While national economies were increasingly knowledge-based, they were also becoming increasingly integrated. Within this global environment, stronger intellectual property rights and more aggressive IP strategies are seen as important steps toward bolstering the global competitiveness of U.S. firms. Indeed, part of the original push for stronger intellectual property rights protection, both at home and abroad, was a defensive reaction on the part of U.S. firms that were losing out to intensified competition from new (mainly Japanese) producers who had acquired surprising manufacturing capabilities. At the time, U.S. firms were sitting on a wealth of intellectual property that was routinely pirated by overseas competitors. Major intellectual property holders recognized that they could strengthen their competitive advantage vis-à-vis their new competitors if they could force them to pay royalties on their copyrighted and patented inventions. They successfully lobbied the U.S. government to threaten trade sanctions against countries that were not enforcing property rights.

1.1.4 R&D collaboration and research productivity

Firms are turning to various forms of collaboration in order to boost the effectiveness and productivity of their R&D efforts. Indeed, the rapid pace of scientific discovery, the growing technological complexity and interconnectedness of products and processes and the higher costs and risks attached to innovation, are making collaboration a necessity. New collaborative research networks and joint ventures are not only forming among firms, but also among firms, universities and public research organizations. The benefits of collaboration include: a) allowing firms to identify scientific discoveries with commercial potential more quickly, b) pooling the competencies of diverse organizations, allowing participants to focus on their area of research competence, c) facilitating mutual learning and knowledge exchange and d) lowering transaction costs associated with technology exchange by placing these cooperative development activities under a common governance structure. Although the data is meager, many firms and observers attest that collaborations have boosted the rate of inventiveness in high-tech industries, which leads to more patents. More intense collaboration has also made patents more important, as participants in innovation networks seek to clearly define the boundaries of their intellectual contributions, and as patents become the basic unit of currency in technology transfers and exchanges.

1.1.5 Start-ups and venture financing

Start-ups and venture capitalists in the IT and biotech industries are also playing a significant role in the patent explosion. R&D statistics from the United States show that R&D in small to medium size enterprises (SMEs) grew at almost twice the rate of R&D in large firms during the 1990s, with the smallest firms increasing the most rapidly. Young firms rely heavily on patents to protect the intellectual capital of the firm. This trend is supported by the increasing availability of venture capital, which acts as both an incentive for, and input into, patent growth. For example, innovation in the biotechnology industry is driven by biotech start-ups that require huge amounts of capital just to cover the R&D phase of product development. In the absence of established links with pharmaceutical incumbents in the early days, venture capital flooded into the industry, helping start-ups make discoveries that provided the basis for subsequent patent applications. More generally, the rise of venture financing in the 1990s acted as a further incentive for young firms to patent by increasing the value of possessing a portfolio of patents. While patents do not guarantee a financing deal, financiers certainly take them as both a signal of creative and engineering competence and a useful barrier to entry in niche markets.

1.1.6 Disruptive technologies

Some of the push for more patents and stronger intellectual property rights is attributable to the recent wave of disruptive technologies that pose serious threats to established IP-business models. In some cases, intellectual property rights have literally become weapons to protect the business models and investments of incumbent firms in IP-rich industries. This is perhaps best illustrated by the ongoing effort by the publishing and entertainment industries to contain the impact of audio compression and peer-to-peer file sharing technologies on traditional publishing and content distribution models. New digital rights management systems (DRM) represent an attempt to impose traditional copyright protections into the world of digital distribution where content is routinely shared for free. Another example is the threat by some software firms to launch patent infringement suits against Linux developers/users.

1.1.7 Transparency

Finally, there may be some role played by rising transparency in reducing the feasibility of secrecy as a mechanism to appropriate the returns from innovation. A large survey of the U.S. manufacturing industry in 1994 found that secrecy was rated second to lead time as a mechanism to appropriate returns from innovation (see section 1.4). Since then, the Internet has increased the availability of information about new technologies and made it easier for firms to find out about and possibly pre-empt the R&D activities of competitors. The flow of information about technology development strategies is also partly intentional—enhanced by a greater emphasis by some firms on openness and collaboration, and by the increasing mobility of employees in high-tech industries who take valuable tacit knowledge with them as they move from firm to firm (despite the fact that such information ought to be protected by trade secrets and employment contracts). Apart from anecdotal knowledge, it is not clear to what degree firms find that secrecy is decreasing as the mobility, collaboration and use of the Internet are increasing. But, to the extent that transparency is a factor, we might expect firms to rely more heavily on patents as a defense.

1.1.8 Conclusions

The factors discussed above contribute to a global economic environment in which intellectual property and innovation are increasingly important drivers of economic opportunity and wealth creation. As evidence that we have entered a new paradigm, we note that scientific discoveries are unleashing new waves of innovation, new technologies are emerging at a faster rate and innovation processes are becoming increasingly complex and inter-networked. Underlying this paradigm is a consensus amongst most industry leaders and public policy makers that strong intellectual property rights provide the incentives required to maintain and bolster the pace of technological advancement. Indeed, as intellectual property and innovation become more central to competitive strategy, most firms believe their interests are best served by maintaining tight proprietary control over knowledge and new inventions.

As we discuss in the following sections, the rising importance of intellectual property protection is illustrated by a growing propensity to patent inventions and attribute strategic value to a large patent portfolio. It is also evidenced by the increasing number of countries extending stronger and broader patent protection to inventions. Many believe that patent protection is essential to securing the returns from innovation, and consequently an inducement to R&D and a driver of economic growth. The belief in these principles is most evident in the U.S. patent law reforms begun in the early 1980s.

1.2 Two decades of U.S. patent law reform

U.S. policymakers began strengthening intellectual property rights in the mid-1980s. Some changes were legislated, while others were established through legal precedent. The outcome is that today, patents are cheaper, stronger, broader and easier to obtain. Many of these reforms have since been emulated by the European and Japanese Patent Offices and are becoming increasingly standardized across countries as international bodies such WIPO and the WTO gain more clout.

Below we discuss four significant reforms and their effect on the patent strategies of firms. Table 1.1 (on page 8) identifies a number of key milestones, some of which we elaborate below.

Table 1.1 Significant legal and legislative reforms since 1980

Year	Legislation/legal precedent and its implications
2004	European Parliament debates new directive on “Patentability of Computer-Implemented Inventions”, as proposed by the European Council and vigorously supported by the European Information and Communication Technology Association
2002	The number of software and business method patents issued by the USPTO reaches approximately 20,000 per year
2000	USPTO announces it will overhaul the review process for business method and software patents, adding a second round of scrutiny and requiring a broader search of past practices and inventions
1999	Amazon.com awarded patents on its one-click shopping system and affiliates program, triggering a backlash against software and business method patents
1998	Court decision in State Street Bank and Trust vs. Signature Financial upholds patent on hub and spoke financial services produce, establishing legal validity of business method patents
1994	Agreement on Trade-Related Aspects of Intellectual Property (TRIPs) initiates legal harmonization drive and improves international enforceability of patents
1986	Kodak vs. Polaroid decision grants Polaroid a $1B judgment and preliminary injunction against Kodak for infringing on an instant camera patent—signals willingness of the Court to sustain large damage awards
1985	Texas Instruments initiates and wins suits against Japanese semiconductor firms for infringement of its protected circuit designs and manufacturing processes, ushering in a broader tendency for patent holders to assert their rights more aggressively
1984	Semiconductor Chip Protection Act creates new form of intellectual property protection for novel chip designs called “mask works rights,” limiting an industry-wide tradition of reverse-engineering
1984	The Hatch-Waxman Act provides incentives to support the development of generic versions of off-patent drugs, while permitting patent owners to recover time lost during FDA approval by restoring one day to a patent for each two days consumed in the regulatory approval process
1982	Creation of the U.S. Court of Appeals of the Federal Circuit centralizes legal administration of patents and establishes pro-patent orientation
1981	Diamond vs. Diehr decision provides first step in establishing the patentability of computer programs
1980	Baye-Dohl legislation extends eligibility to patent to universities and R&D labs that receive public funding
1980	Diamond vs. Chakrabarty establishes patentability of genetically-engineered organisms or life-forms

1.2.1 *Pro-patent orientation and broader patent protection*

One of the most significant reforms in the U.S. patent system was the creation of the U.S. Court of Appeals of the Federal Circuit in 1982. This was important for several reasons. First, legal administration of the patent system was centralized, providing more uniform and predictable treatment of patent cases. Second, the court was considerably more patent-friendly. This transformed the legal environment from one where it was common for patents to be invalidated by the courts to one where the courts promoted the broad, exclusionary rights of patent owners. Robert Merges, for example, argues that the new court applied a broader interpretation of patent scope and made it more difficult to challenge a patent’s validity by raising evidentiary standards.[3] Third, some legal observers claim that the standard of non-obviousness for new inventions applied by the USPTO and upheld by the court has been substantially relaxed, making patents easier to obtain and therefore lowering the average cost of creating a patentable invention.[4]

1.2.2 *Stronger and more frequently enforced property rights*

The new court was willing to grant preliminary injunctions and confer large damage awards in patent infringement cases. This effectively made patents stronger and more enforceable, raising the expected value of patents in the eyes of would-be inventors. One noteworthy legal precedent was Polaroid vs. Kodak. Polaroid sued Kodak for infringing its instant-film camera patent and was awarded almost $1 billion in damages. Moreover, Kodak was barred from competing in the instant-film camera business. Prior to the Kodak-Polaroid case, firms typically expected to pay royalties on the past use of property covered by an infringed patent. The realization that the court was willing to levy an injunction that would halt production made firms re-evaluate the costs and risks associated with patent infringement. High-tech firms in a range of industries noted that the costs associated with being "held-up" by an injunction after sinking considerable resources into the design, manufacture and marketing of a new product, even on a temporary basis, could be very high indeed. The case is thus widely acknowledged to have played a role in heightening the strategic value of holding a large portfolio of patents. Large patent portfolios could be used both offensively against competitors and defensively against potential infringement suits by providing a bargaining chip to use in cross-licensing negotiations.[5]

1.2.3 *Extending the eligibility to patent to public research organizations*

Another significant change in the U.S. patent system was the decision to extend the eligibility to patent new inventions to universities and government-funded R&D labs. The main feature of the controversial Baye-Dohl Act was to transfer title to any invention made with the use of government-supplied funds from the government to the universities where the research was conducted. Previously, the U.S. government had usually insisted on taking title to such inventions and putting them in the public domain. The Act facilitates technology transfer between universities and industry by ensuring that property rights to new inventions are well-defined, materially rewards university scientists for their breakthroughs and provides universities with revenue through licensing fees for their patents. Industry-university collaboration is generating much technological progress and commercial success in a range of high-tech industries, particularly biotechnology.

1.2.4 *Extending the coverage of intellectual property protection*

Finally, the patent system has had to adjust to the rapid pace of discovery and invention in high-tech industries. Since the late 1970s technological advances have outpaced the patent classification systems of national patent offices. As a consequence, there has been much uncertainty surrounding the patentability of significant new discoveries in high-tech industries, some of which were initially ineligible for patent protection. Over a twenty-year period, a combination of legislation and legal precedents sought to accommodate new technological realities by extending patent coverage to new life forms, software, semiconductor designs, business methods, and most recently, nanotechnologies. We expand briefly on these reforms since each has a significant bearing on one or more of the industries we examine throughout the paper. [Readers not interested in such detail can safely skip to the next section.]

The legal precedent that helped give birth to the modern biotechnology and biomedical industry was the U.S. Supreme Court decision in Diamond vs. Chakrabarty that established the patentability of genetically modified organisms. Chakrabarty, an employee of General Electric at the time, made a unique advance by developing a bacterium that could degrade oil and potentially prove useful for cleaning up oil slicks. But microorganisms were considered products of nature, and therefore not subject to patent law. Chakrabarty challenged the Patent Office's decision to reject his patent, claiming that by genetically engineering the organism to give it the capability to degrade oil he had produced a novel bacterium that could not be found in nature. The Supreme Court concurred, ruling that genetically modified organisms were human inventions and therefore patentable subject matter. This cleared the way for others to seek patent protection for genetically modified organisms.[6]

The extension of patent protection to software was a more gradual process. During the 1970s, federal court decisions typically described computer programs as mathematical algorithms, which, at the time, were unpatentable subject matter under U.S. patent law (see discussion of business method patents below). Systems using software could be patented—and many were—but only if the novel aspects of the invention did not reside entirely in the software (indeed, for a long time most software patents were owned by hardware firms that wrote applications for their hardware devices). This does not mean that "pure" software inventions were unprotected. They were, except by copyright laws that protected software as literal expression and legally prohibited reproduction of the software code. Copyright could not, however, prevent competitors from replicating the features or functionality of a program so long as it was executed with unique code. Over time, the effectiveness of copyright protection faded and patents gradually replaced it as a means to shield software innovations from competitors.[7] The first successful challenge to the subject matter exception restricting patents on software-related inventions emerged in the Diamond vs. Diehr case in 1981. A series of subsequent decisions eliminated any remaining uncertainty by 1998 and patents now provide the dominant mode of protection for new software inventions today.

Patent protection was extended to the semiconductor industry with the Semiconductor Chip Protection Act of 1984 (SCPA). Prior to then, patents were rare because most new semiconductor designs did not satisfy the test of non-obviousness applied by the courts (in large part because the rapid pace of innovation proceeded through small incremental improvements to chip design and performance that did not fundamentally alter the design of the chips). Weak patent protection, on the other hand, contributed to an industry-wide tradition of reverse engineering, which was largely tolerated until Japanese firms began to pose a serious threat to U.S. manufacturers during the late 1970s. Two events dramatically altered the course of patent strategies in the semiconductor industry. First, in the mid-1980s, Texas Instruments began to aggressively assert its IP rights by suing close to a dozen Japanese semiconductor manufacturers, a practice that was previously uncommon. Second, around the same time, the SCPA introduced by Congress granted firms exclusive rights to reproduce, distribute and manufacture unique semiconductor designs (called 'mask works') for a period of 10 years, while infringements were punishable by injunctions, repatriation of lost profits and sanctions up to $250,000. The standard of non-obviousness applied for mask works is considerably weaker than the one for patents. This relaxed standard aims to strike a balance between protecting the economic rents of innovators and encouraging firms to build freely upon past inventions.

Perhaps most controversial was the decision to allow patents on business methods. This precedent was set in 1998 in State Street Bank and Trust vs. Signature Financial Corporation. The decision dashed the requirement for a patentable invention to entail some form of physical transformation or a physical embodiment. Mathematical algorithms and methods became patentable so long as they were "embodied" in an invention, whether physical or virtual. The controversial part is not so much that patents can be obtained on purely abstract ideas or algorithms with a new and useful application, as the fact that many consider a large proportion of business method patents to be either obvious, not particularly novel, or both. Such patents now encompass a variety of functions, including:

- Financial products and services such as credit and loan processing systems and financial instruments such as derivatives;
- Marketing techniques and systems such as incentive programs and cataloguing systems;
- Information management and optimization systems for resource planning, accounting and inventory management;
- E-commerce tools such as user interfaces, auctions, electronic shopping carts and affiliate programs;
- Online voting systems, games, gambling and training programs.

High-profile business method patents include Amazon.com's one-click shopping patent, the Dutch auction patent awarded to Priceline.com, and the Signature Financial patent on a system for managing multiple mutual funds in a single account.

1.2.5 Conclusions

All considered, changes in the U.S. patent system amounted to a minor revolution in intellectual property law. Some of the changes made patents stronger by making them more enforceable and more likely to be held up in court. Some of the changes made patents easier to obtain by lowering the standards required to obtain them. Further changes expanded the boundaries of who can patent and what can be patented. The net effect was that patents became more cost effective for a wider group of individuals and organizations, and a more expansive realm of new inventions. Combining the changing legal environment with the changes in the economic, business and technological environments, we see a dramatic boost in the incentive to patent. So it is not surprising that the number of USPTO patents issued annually has increased rapidly since the mid-1980s. What is more surprising is the fact that these incentives have been internalized quite differently across industries. We now turn to take a closer look at the patent explosion and the propensity to patent in a sample of high-tech industries.

1.3 Mapping the patent explosion

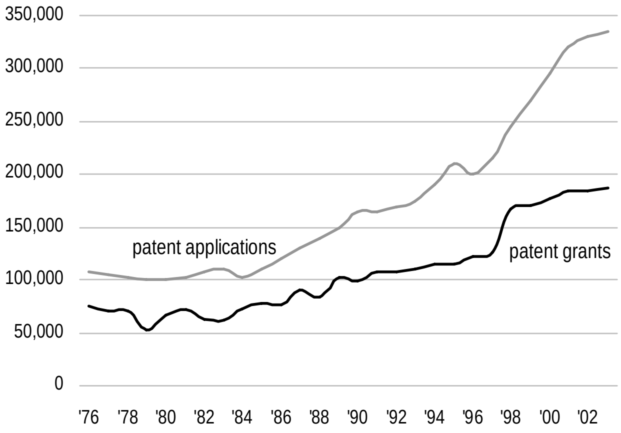
In this section we conduct a number of "time-series" analyses, looking at the aggregate number of patents issued by the USPTO across different classes of technology. We look at a 28-year period from 1976 to 2003, which allows us to detect changes in patenting behavior that may have been caused by changes in both the economic and legal context. We take several cuts at this data, highlighting significant trends.

As expected, the big picture reveals a significant surge in the rate of patenting by U.S. firms beginning in the mid-1980s. More importantly, we find that the growth of IT patents outstrips any other technology category. We also find that IT firms patent more per dollar invested in R&D than firms in other industries, and that this propensity has grown over time. Both of these results are considered in light of survey evidence discussed in section 1.4 that reveals the IT industry's relatively low value placed on patents as a mechanism to appropriate returns from innovation.

1.3.1 Patent grants and applications in the United States, Europe, and Japan

Figure 1b shows the total number of patent applications and grants for all U.S. utility patents between 1976 and 2003. The rate of patent applications and grants is relatively constant until the mid-1980s, with an average growth rate of 0.3%. Indeed, if we were to extend the timeline back as far as 1950 we would see no appreciable increase in the rate of patent applications and grants until the early 1980s. From 1985 onward the graph exhibits a substantial break with past trends. The growth rate of applications averages 6.5% and the grant rate averages about 6% per year. Thus, as patent applications have grown, the proportion of applications granted has gone down from about 70% in 1976 to 56% in 2003.

Figure 1b Patent applications and grants by the USPTO, 1976–2003



By comparison, patent applications to the European Patent Office totaled nearly 110,000 in 2002—about a third of the applications submitted to the USPTO—but grew at an average rate of 4.8% between 1985 and 1993, and 7.8% since 1993. The Japanese Patent Office has not experienced similarly high growth rates when one considers patent application numbers alone. But, reforms in 1988 allowed applicants to include several unique claims in one patent application. When filings are adjusted for the number of claims we find that the total number of claims has doubled between 1995 and 2001. Overall, we find that patent numbers at the EPO, JPO and USPTO have fallen or slowed sharply since 2000 as the economic situation in the OECD has deteriorated. Nevertheless, more than 850,000 patent applications were filed in Europe, Japan, and the United States in 2002, up 40% from 600,000 in 1992.

1.3.2 Patents in high-tech sectors

Disaggregating U.S. patent data by technology classes and industries reveals a number of interesting findings. The first finding is that while inventiveness has been increasing across most classes of technology, the rate of patent growth is not even. IT patents account the largest share.[8] Biotechnology patents are also an exceptional category, exhibiting especially rapid growth throughout the 1990s. We take a closer look at both of these patent categories below, beginning with the IT industry.

Figure 2 shows that the annual number of IT patents issued by the USPTO has been growing steadily since the early 1980s with an average annual growth rate of 10.3% (substantially above the 6.0% growth of overall patent grants). In 2003, the USPTO issued nearly 70,000 IT patents, almost six times as many as were being issued during the late 70s and early 80s.

Figure 2 IT patents granted by the USPTO, 1976–2003

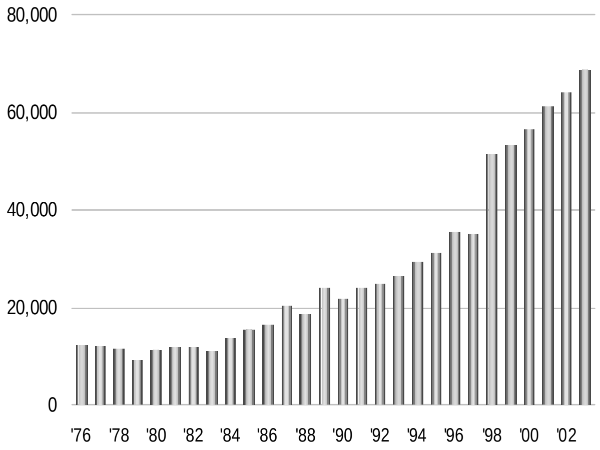


Figure 3 reveals that IT patents are not simply rising with the overall tide of patents. Rather, IT patents have grown significantly as a proportion of overall patents issued by the USPTO, and are now approaching close to 40% of patents issued on an annual basis. Both the proportion and the growth rate of IT patents issued by the EPO are similar in magnitude at 35% and 9.5% respectively. According to the OECD, roughly half of the growth of patenting at the EPO can be accounted for by growth in IT patents.[9] In Japan, IT patents account for nearly 45% of all patents issued by the JPO.

Figure 3 Total IT patents as a proportion of USPTO patent grants, 1976–2003 (reforms since 1980)

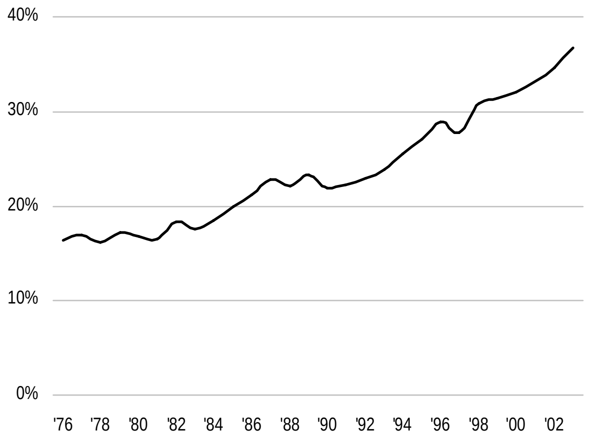
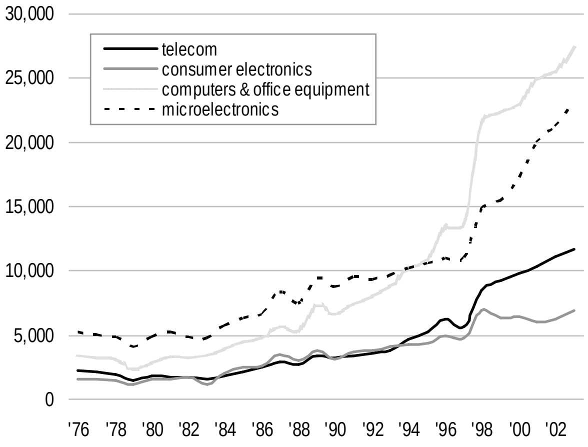


Figure 4 disaggregates total IT patents into its sub-classes. While all sub-classes have grown, patents in the 'computers and office equipment' and the 'microelectronics' categories grew more rapidly and account for a larger share of the IT category than 'telecom' or 'consumer electronics' patents. Another finding is that with the possible exception of consumer electronics, patent applications and grants in these IT sub-classes have not slowed down as much as the application and grant rate observed in other categories such as biotechnology (see Figure 4 on page 14). The fastest growing sub-class of IT patents, computers and office equipment, grew at a rate of 15% per year throughout the 1990s, and has

Figure 4 Sub-classes of IT patents issued by the USPTO, 1976–2003

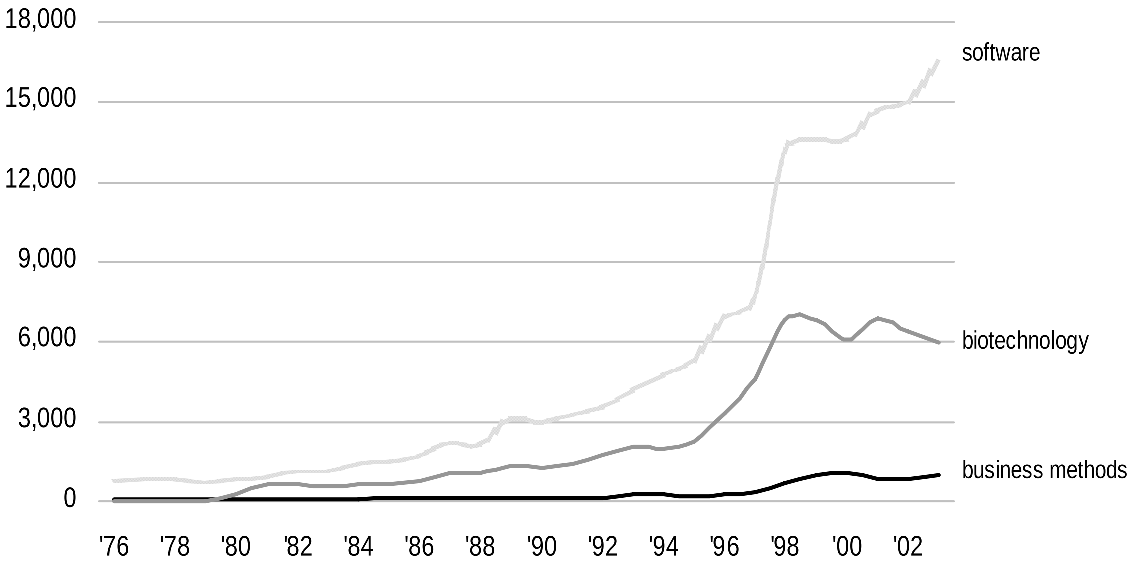


grown by 6% annually since 2000, still above the 4.4% growth rate of overall patent grants over the same four year period. On the other hand, patents in the microelectronics category have an average annual growth rate of 10.5% since 2000, a substantial increase from the rather stagnant period in the early-to-mid 90s. While not shown here, the USPTO recently reported that patent applications for semiconductor designs or "mask works" are growing by 20% per year, reflecting the rise of specialized semiconductor design firms that have flourished since the introduction of the Semiconductor Chip Protection Act.

1.3.3 Software, business method, and biotech patents

Software patents are not delineated in Figure 4. This is partly due to how software patents are categorized by Patent Offices, how firms file software patents and that software is increasingly pervasive. Recent estimates indicate that between 25 - 40% of all industry-financed R&D has a software-like outcome, reflecting the fact that software is central to most industrial control systems and embedded in an increasing number of objects. As a result, software-related patents can be found in all of the sub-classes of IT patents tracked above, in

Figure 5 Software, biotech, and business method patents issued by the USPTO, 1976–2003



the business method class, and in many other classes as well. Indeed, less than 10% of software patents issued by the USPTO are awarded to software firms, although this percentage continues to grow as business consultancies, "pure-play" software firms and start-ups join the software patent race.

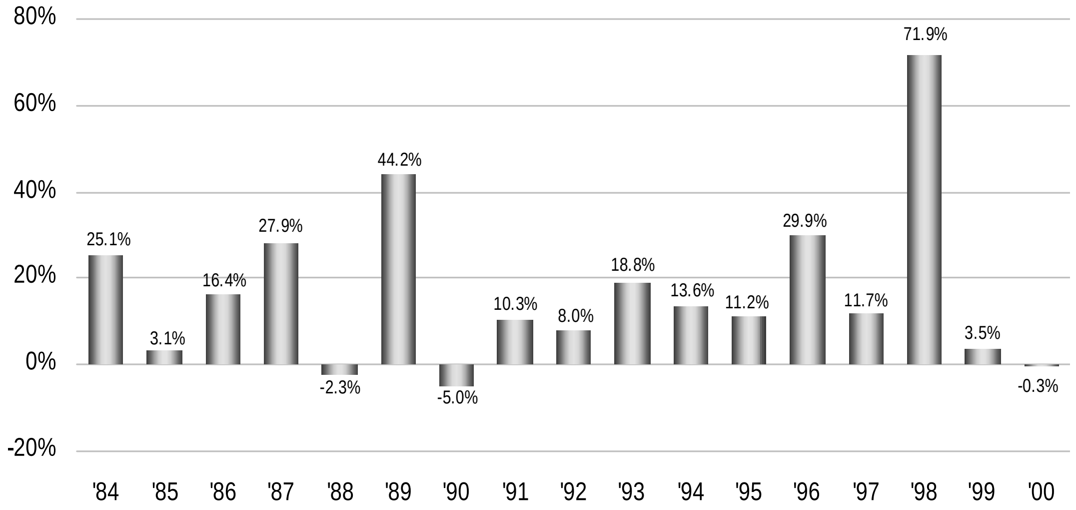
To avoid double counting above, we identify software patents issued by the USPTO separately using our own search strategy. Figure 5 plots these software-related patents, as well as biotechnology patents and business method patents, which we discuss below. While not everyone agrees on how software patents should be counted, our numbers lie roughly in the middle of other published estimates.[10] Using the year 2000 as the baseline, Bessen and Hunt, for example, estimate that roughly 20,000 software patents were issued by the USPTO. Bronwyn Hall puts the figure much lower, estimating that just over 10,000 software patents were issued in 2000. Our figures suggest the number for 2000 is closer to 14,000. We estimate that the total number of software patents is around 170,000.

Our research shows that the number of software patents issued annually has been growing rapidly since the late 1980s. In 1976, software-related patents constituted about 7% of IT patents, and just over 1% of all patents issued by the USPTO. Today, they represent about 25% of the overall IT patent count, and nearly 10% of all patent grants.[11]

Figure 6 plots the annual growth rates of software patents between 1984 and 2000. The average growth rate for this period was about 15%. It is probably little coincidence that the period of consistent growth starting in 1991 coincides with the series of court cases that weakened copyright protection for software (described in section 1.2), making patent protection increasingly attractive. Indeed, the massive growth of software patents in 1998 appears to reinforce the importance of the State Street decision to allow patents on "non-embedded" mathematical algorithms discussed previously.

While the growth rate dips sharply after 1998 (i.e.,

Figure 6 Annual growth rates of software patents, 1984–2000



around the time of the dot-com collapse), we expect software patents will continue to grow swiftly in the immediate future. The latest patent stats show growth picked up in 2003, with a 9.5% increase in software patent grants over 2002. A tentative count for 2004 (current as of November 1, 2004) indicates a further increase of at least 5% over the 16,500 software patents issued in 2003. Microsoft alone, which has only recently begun to patent its software, has announced that it will have filed 3,000 patent applications by the end of 2004, up from 2,000 in 2003 and 1,000 in 2002. Approximately 40% of the patents in IBM's annual harvest of over 3,000 patents are software-related and this number will likely remain steady in the near future.

Despite their high profile, pure business method patents, (U.S. class 705) depicted in Figure 5, represent a fairly trivial contribution to the overall universe of patents. Altogether, there are nearly 10,000 such patents, and probably less than 6,000 of these could reasonably be classified as "Internet-patents," such as the one-click shopping patent awarded to Amazon.com. Indeed, after nearly tripling between 1997 and 1999, applications for business method patents have since fallen. One observer suggests, however, that the relatively low number of business method patents reflects a strategic calculation by firms to redirect their patents to other categories to avoid the second patent application review stage that was recently added to improve the quality of these patents.

Biotech patents got a later start than IT patents generally, and did not gather momentum until the mid-1990s. The tremendous average annual growth rate of 20% throughout the 1990s clearly has a great deal to do with the fusion of biotech and IT (bioinformatics), which greatly accelerated the information processing and boosted the speed at which new discoveries could be identified, as well as the entry of biotech start-ups specializing in research and discovery. The rate of growth of biotech patents issued by the EPO was lower at 10.5% throughout the 1990s, but still significant. It is worth noting that biotech patents are distinguished from IT patents by the major role played by public research organizations (PROs) such as universities, which account for over 30% of all of the biotech patents issued by the USPTO and EPO since 1996.

Oddly, the number of patents issued in the biotechnology class has actually declined since the late 1990s. In 2003, less than 6,000 new biotech patents were issued, down from a peak of 6,800 in 1998. The scientific journal *Nature* attributes the recent decline to the completion of the Human Genome Project and pressure from Patent Offices for clearer patent applications. Most industry observers agree, however, that the growth of biotech patents is set to surge again as researchers continue to exploit information from the human genome and other recently sequenced plant and animal genomes.

1.3.4 Insights from the comparative growth analysis of patents across industries

The growth of patents in the IT industry outstrips all other comparable industries. Indeed, no other industry comes close when you take into account its year-over-year growth in the number of granted patent applications and its increasing share of overall patents grants. For comparison, Figure 7 shows each patent sub-class (excluding business method and software patents to eliminate double counting) as a proportion of all patents issued annually by the USPTO between 1976 and 2003. It is interesting to note how biotechnology lags below all of the IT patent sub-classes as a proportion of overall patent grants and is the only category dropping.

Figure 7 Various patent classes as a proportion of patent grants, 1976–2003

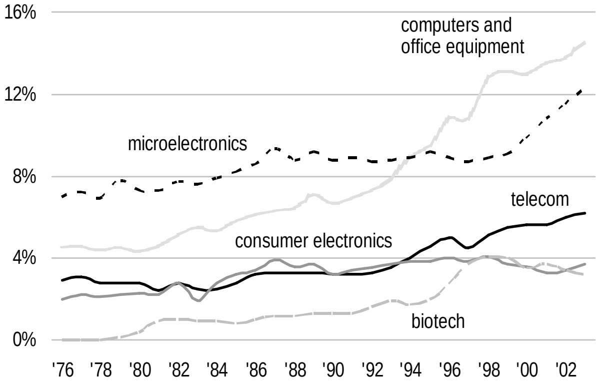
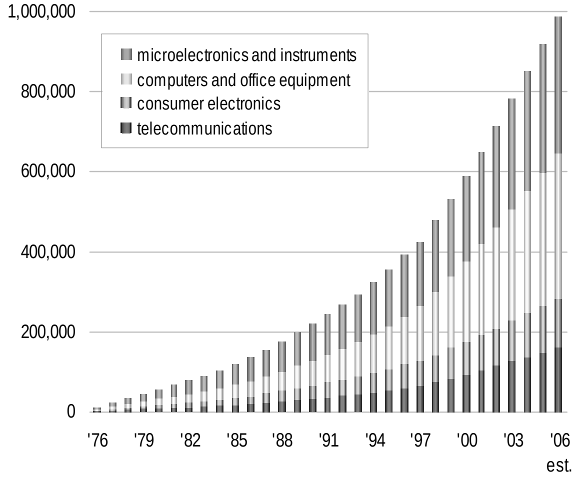


Figure 8 shows the cumulative growth of IT patents issued by the USPTO reached a staggering 782,000 patents as of 2003 and will easily surpass 1,000,000 in the next three years, even if we assume that growth rate remains flat (i.e., that the same number of patents in each category will be granted in 2004–2006).[12] This, of course, does not even include IT patents registered in Europe, Japan, India, China, and other emerging economies, that were not also registered with the USPTO.

We also note that empirical research documenting various facets of the patent explosion reaches similar conclusions, including a recent paper published by Bronwyn Hall of University of California, Berkeley. Indeed, Hall's growth accounting exercise, which matches patents to firms in the Compustat database, reveals an even more striking finding. Like our analysis, Hall finds that after 1998, patents in the IT technology class began to account for roughly 35% of all USPTO patents.

Figure 8 Cumulative growth of IT patents issued by the USPTO, 1986–2006



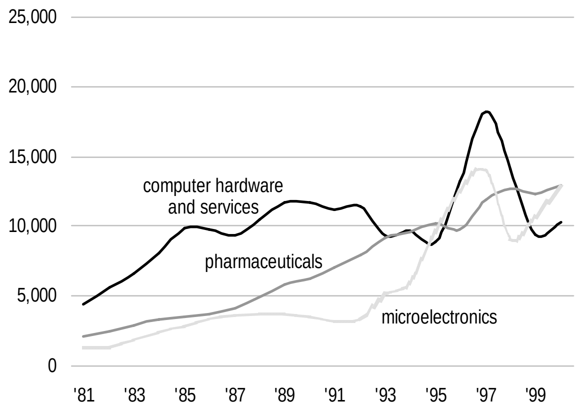
However, when the unit of analysis shifts from patents in broad technology classes to patents held by firms in broad industry classes, Hall finds that firms in the IT industry (including consumer electronics, microelectronics, computers and telecommunications) account for nearly 54% of the patents issued by the USPTO. When measured this way, the growth in patent applications witnessed in chemicals, mechanical and other technologies appears to be driven partly by increasing patenting activity by firms not traditionally in these industries. This implies that IT firms increased their patenting not only in their own sector but in other technology sectors as well.

1.3.5 The propensity to patent

What does this analysis reveal about the strategic use of patents in the high-tech industries, and the IT industry in particular? As noted earlier, industry-financed R&D spending in the U.S. increased 400% between 1981 and 2000. The fact that the patent surge occurred mainly in sectors of the economy where the rate of inventiveness appears to be especially high suggests that patent numbers might simply reflect trends in invention and R&D spending. To see if this is true, we examine the R&D expenditures of firms known to patent in the technology classes where patents have been growing fastest (i.e., computers and microelectronics) and compare it with R&D spending in the life sciences industry.

Figure 9 shows the aggregate R&D expenditures for firms in the computer, microelectronics, and pharmaceutical industries between 1981 and 2000 (the latest reliable figures). As one would expect, spending has grown in each category along with the general tide of R&D spending.

Figure 9 Business R&D expenditure by industry (million current USD), 1981–2000



Over the twenty-year period we examine, absolute spending more than doubled in the computer and office equipment industry, grew six-fold in the life sciences sector and increased by 10 times in the microelectronics industry.

Figure 10a gives us a different perspective showing the same figures represented as a proportion of overall business expenditure on R&D (we include Figure 10b for the sake of comparison). Here we see that the proportion of R&D spending in the computer industry is now considerably lower than it was throughout much of the 1980s, and certainly not as high as we might expect when we consider the proportion of patents now attributed to these firms.[13] The life sciences sector has increased its share of R&D spending by a considerable margin, but, as noted earlier, its share of patents has not. R&D spending in the

Figure 10a R&D as a proportion of overall business R&D (million current USD), 1981–2000

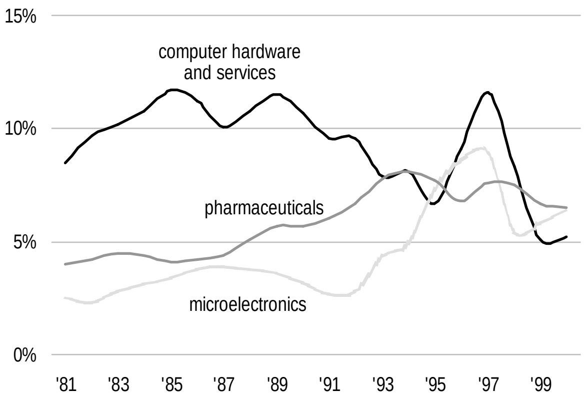
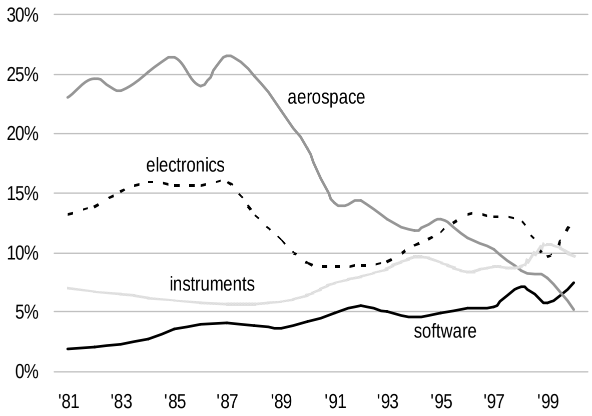


Figure 10b R&D as a proportion of overall business R&D (million current USD), 1981–2000



microelectronics industries has also grown as a proportion of overall spending, but perhaps not as much as the growth in its proportion of overall patent grants. This leads us to believe that increases in R&D spending in high-tech industries cannot explain all of the increases in patent grants. A closer look at the ratio of patents to R&D spending ratios (patent propensities) for these industries reveals why.

Figure 11 shows the patent propensity ratio for all R&D performing U.S. firms from 1981 to 2000. Somewhat surprisingly, we find the average propensity to patent has remained relatively constant for U.S. firms as a whole (hovering between 0.5 to 0.7 patents per million dollars of R&D spending), despite changes in the legal and economic environment that encouraged firms to seek patents.

Figure 11 Patents per million R&D dollars, all U.S. firms, 1981–2000

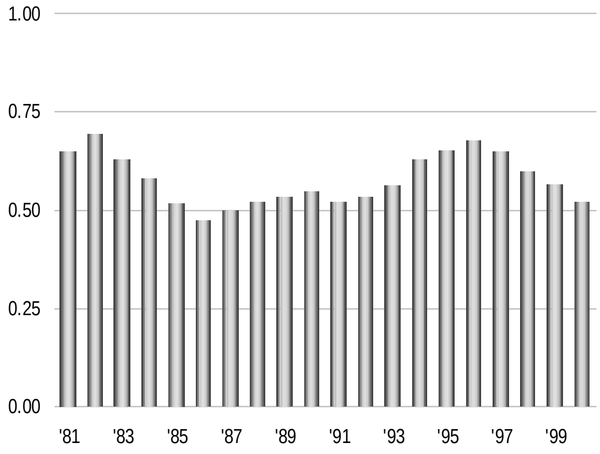
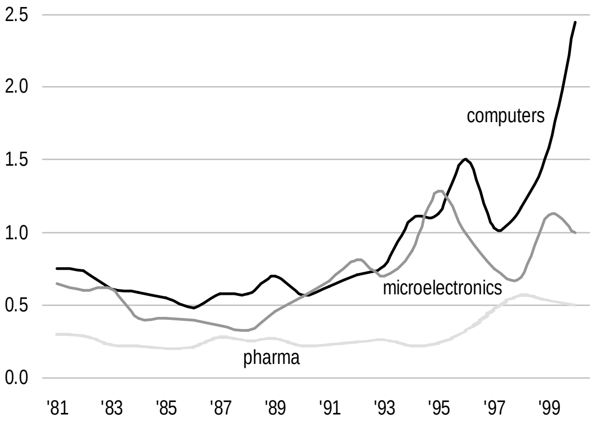


Figure 12 compares the patent propensity ratios for firms in the computer and office equipment industry, the microelectronics industry and the life sciences industry. Patent propensities for firms in the computer and office equipment industry tracked the average rate until about 1993. The propensity to patent has risen sharply since then to a point where a million dollars of R&D now generates nearly 2.5 new patents. The patent/R&D ratio for the microelectronics industry rises and falls over time, reaching a high of nearly 1.3 patents per 1 million R&D dollars in the mid-1990s and falling back to an average ratio of about 1 in recent years. The propensity to patent in the bio-pharma industry is low, and only just catches up to the average in the mid-1990s. The change in this ratio over time likely reflects the shifting balance between the "negative" effect of high R&D spending and the "positive" effect of the genomics revolution on research productivity.[14]

Figure 12 Patents per million R&D dollars, by industry, 1981–2000



The patent yields of IT firms are well above the average for other comparable R&D intensive sectors.[15] Indeed, the patent propensity ratio for firms in the computer and office equipment sector is currently more than four times that of firms in the life sciences sector. Yet, of the three sectors we examined, R&D spending in this sector increased the least, while, as noted, it actually declined as a proportion of overall spending.

One way to account for the fact that patent rates surged in the IT industry would be to assume that the productivity of R&D increased as firms improved the way they manage the innovation process. But, unless research conducted in the computer industry is dramatically more productive than research in other R&D intensive industries, these findings suggest a different conclusion. Rather than reflecting a comparatively large surge in the rate of invention per se, it seems more likely that the patent surge reflects a broader managerial and strategic shift that emphasizes the need to harvest as many patents as possible out of their R&D dollars. In other words, managerial improvements occurred in how firms manage R&D outputs (i.e., the patent identification and application process), and not necessarily the R&D input side of the innovation process.

This observation is supported by the fact that over the same time period many IT firms overhauled their patent procedures by hiring in-house patent attorneys, rewarding employees for patentable inventions, and setting up internal patent committees to support a more aggressive "patent mining" strategy. Our conclusions are also supported by the observed tendency (which we discuss shortly) for firms in the IT industry to amass large patent portfolios to allow them to engage in cross-licensing negotiations on more favorable terms. While the above findings warrant further testing, they raise a number of questions about the impetus for these changes in the relative importance of large patent portfolios to IT firms. Have patents suddenly become more instrumental in protecting new inventions? Or, are other strategic factors driving the patent explosion? We address these questions in the next section.

1.4 Appropriating returns from innovation: how firms profit from intellectual property

At first glance, it is difficult to reconcile a glaring paradox in the patent explosion: while the rate of patenting is growing rapidly, substantial evidence suggests that the absence of patent protection would have little impact on the innovative efforts of most firms in most industries. Recent survey research provides two surprising insights into the value firms attribute to patents. First, patents are not the exclusive, or even the primary, device for protecting inventions in most industries, and second, that some industries (especially pharmaceuticals) rely much more heavily on patents than others. These results raise questions about why the IT industry is seeking more and more patents despite doubts about the effectiveness of patents to secure profits from innovation.

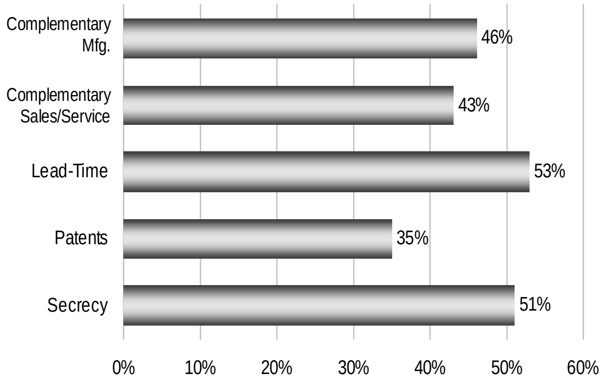
For answers we look to three different sources of research. First, we briefly review results from a major survey of R&D labs in the U.S. manufacturing sector conducted by Cohen, Nelson, and Walsh of Carnegie Mellon University in 1994 (the CMU survey). This survey provides insight into the varying levels of effectiveness attributed to different appropriation mechanisms across different industries, as well as the reasons why firms choose to patent (and not to patent) new inventions. Second, we review testimony from our interviews with R&D managers and Intellectual Property Officers from leading firms in our vertical industries. Third, we look at what economics literature has to say about how firms derive competitive advantages from technological inventions and compare these insights with the assumption that underlie patent law. As we will see, these theories converge on some points and diverge on others.

1.4.1 Comparing appropriation mechanisms across industries

The CMU survey is one of few large-scale surveys that investigate the various ways in which firms enhance and protect competitive advantage through innovation. The 1994 survey sampled 1,478 U.S. manufacturing firms across 34 industries. The survey considered five main appropriation mechanisms: patents, secrecy, lead-time, complementary manufacturing and complementary sales and service. It asked respondents to report the percentage of their product or process innovations that each appropriation mechanism had protected the "firm's competitive advantage from those innovations" during the prior three years. In the charts below, we have extracted information about 10 industries from the overall sample of 34 industries.

Figure 13 shows the overall ranking of appropriation mechanisms in the total sample of 34 industries. Patents rank last. R&D performing firms across all industries report that lead-time, secrecy and complementary capabilities are more effective.

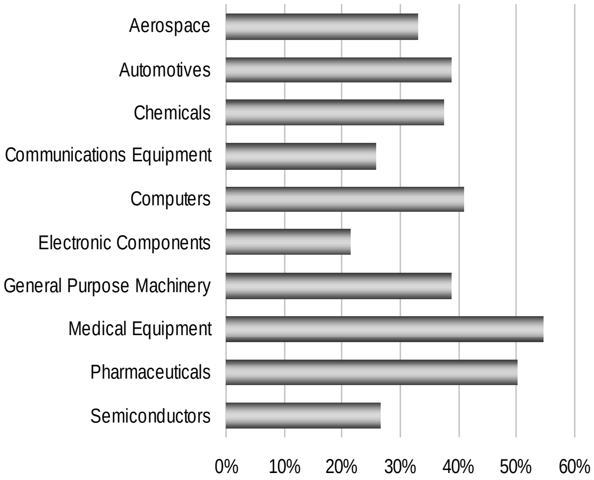
Figure 13 Percentage of innovations for which competitive advantage is protected or enhanced by various appropriation mechanisms



These figures confirm the overall proposition that, by themselves, patents protect a comparatively small proportion of the proprietary edge that firms generate from innovation. There are significant exceptions and nuances within these aggregate figures, however. Figures 14–18 illustrate the differences by showing the average responses for each appropriation mechanism across ten industries.

Not surprisingly, patents protect a much larger proportion of inventions in the pharmaceutical and medical equipment industries than other industries (see Figure 14). Even still, firms report that only 50 and 54% of inventions, respectively, are protected effectively this way. Next highest on the list is the computers and office equipment industry, where firms report an average of 41% of inventions receive effective protection from patents. The fact that each of these industries also reported high scores for other mechanisms suggests that patents on individual inventions are most effective when they are combined with other strategies such as secrecy and complementary sales.[16] These findings

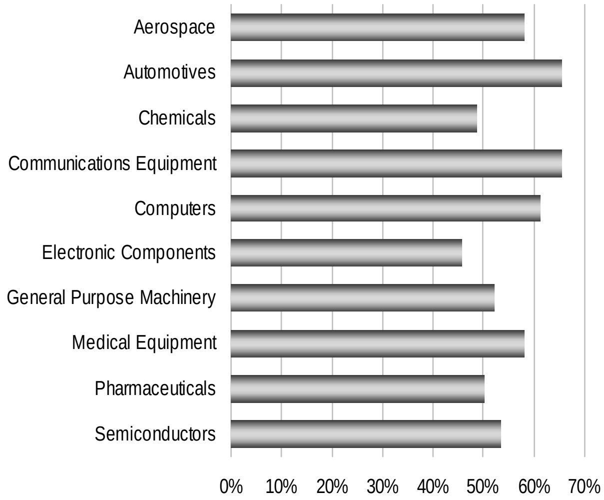
Figure 14 Percentage of innovations for which competitive advantage is protected or enhanced by patents



support the view that patents play an important role in securing the return from innovation in only a select group of industries, most notably medical and pharmaceuticals. They also suggest that other industries obtain patents for strategic and defensive reasons apart from the role they play in providing exclusive access to the monopoly rents associated with licensing or commercializing a new invention. We explore some of these alternative uses of patents such as "patent blocking," cross-licensing and preventing infringement suits below.

The principal way firms gain a competitive edge from R&D is by relentlessly exploiting the learning curve and lead-time advantages of being the first to develop a new product or technology. While the results show that lead-time ranks highly across all industries (see Figure 15), it appears to be the dominant appropriation mechanism in computers, automotives and communications equipment, and a significant factor in aerospace, medical equipment and semiconductors. The relative importance of first-mover advantages in these industries may reflect varying drivers, but all share the fact that vigorous competition and the rapid pace of innovation reinforces the importance of being cutting edge. A firm with a novel invention can sometimes earn a supranormal return for years if it can move quickly enough down the learning curve to keep its product prices and quality a few steps in front of its competitors.

Figure 15 Percentage of innovations for which competitive advantage is protected or enhanced by lead-time



We received strong confirmation of the value that firms place on lead-time in our interviews with firms in R&D intensive industries. One Honeywell executive's reflection on lead-time was indicative of the prevailing view:

> "We innovate because we need to stay ahead of the competition in all of our markets. That's how we maintain our positions. That's how we maintain our competitiveness. That's how we keep our customers. That's how we please our customers... It is the continuous ability to innovate, to provide new technology and new products that makes us a strong company."

Secrecy was deemed to be most effective in the aerospace and semiconductors industries, and to a lesser degree in chemicals, pharmaceuticals, and automotives (see Figure 16). The value of secrecy reflects an important trade off between patenting a new technology and keeping it secret. Patents provide limited exclusivity, but only in exchange for disclosure. Secrecy ranks so highly because firms are concerned that disclosing their invention via a patent will enable competitors to promptly invent around the patent or to infringe the patent without being detected. Indeed, disclosure of critical information is one of the leading reasons why firms

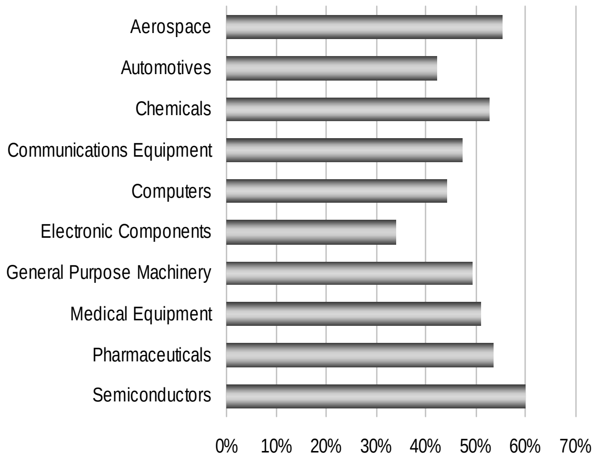


Figure 16 Percentage of innovations for which competitive advantage is protected or enhanced by secrecy

in the overall sample choose not to patent new inventions, and for 24% of the sample it was the leading reason (see below). In industries like the semiconductor industry where competitive advantages are derived, in large part, from superior manufacturing capabilities and process technologies, this reliance on trade secrets makes sense.

A former Intel executive, for example, explains that Intel's decision to patent new inventions hinges on many factors, but crucially revolves around the ease of inventing around the patent, the ease of detecting infringement, and whether the technology will be obsolete by the time a patent is issued. Not only is the rate of product obsolescence particularly rapid in the semiconductor industry, it is also often difficult to detect infringement (particularly in the case of patents on process technologies) because it is often very hard to discern the manufacturing process by simply looking at the end product. Reflecting on his time at IBM and Lucent, Daniel McCurdy (now CEO of Thinkfire) explains that, "If we couldn't discover [infringement], we didn't patent [a new invention], because we couldn't enforce it. That is, we couldn't enforce the exclusion and we couldn't license it because we couldn't prove that competitors are infringing." As a consequence, many inventions in the IT industry, especially process inventions, remain closely guarded trade secrets.[17]

In our sub-sample of 10 industries we find that only firms in the electronic components industry report relying chiefly on complementary capabilities to appropriate returns from innovation (Figure 17 and Figure 18 on page 29).[18] However, while rarely top among the appropriation strategies, firms across all industries report relying on either complementary sales and service or complementary manufacturing for about 40–50% of their inventions. This is particularly true of firms that also rely heavily on lead-time advantages, providing support for the notion that successful innovators must also marshal (but not necessarily own) the production and marketing capabilities on a scale needed to move rapidly and strongly into the latent market. This suggests that the magnitude of the proprietary edge that firms gain from innovation depends on a) the ability to

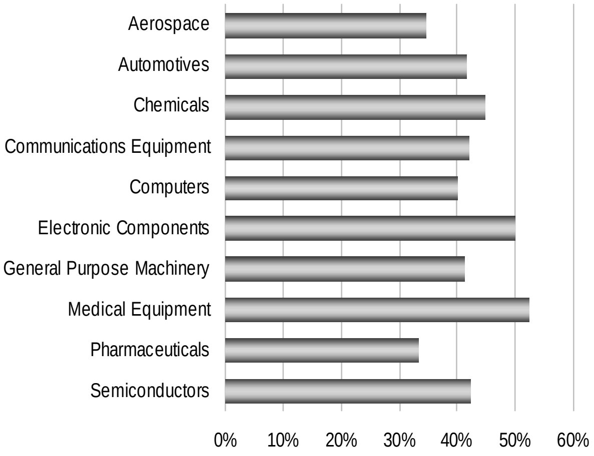
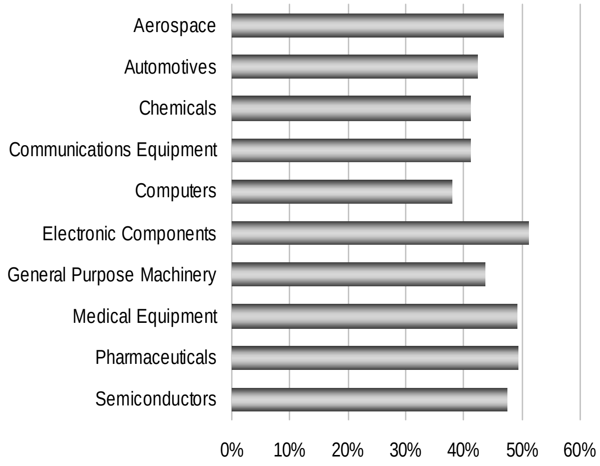


Figure 17 Percentage of innovations for which competitive advantage is protected or enhanced by complementary sales or service

Figure 18 Percentage of innovations for which competitive advantage is protected or enhanced by complementary manufacturing



get there first, and, just as importantly b) possessing the complementary capabilities required to exploit the lead-time advantage. To be sure, firms rely on more than just one mechanism and are likely to adopt different mechanisms to protect the same invention over time. Chemical firms, for example, may initially rely upon secrecy prior to commercializing a new product, but subsequently seek to retain competitive advantage through patents and/or complementary marketing capabilities. IT firms may depend initially on a patent to provide sufficient lead-time to develop or acquire the complementary capabilities required to maintain an edge over their competitors. We interpret the finding that no industry relies exclusively on patents to mean that patents are used chiefly to enhance and extend the effectiveness of other mechanisms such as lead-time. This partly explains why, although being judged relatively ineffective, patents are applied for as often as they are; they simply add sufficient value at the margin. To explore this idea further we examine some additional results from the survey and consider the testimony gathered from IT executives.

1.4.2 Strategic reasons for patenting new inventions across industries

Since patents rank low among appropriation strategies, why do firms patent as much as they do? The Carnegie Mellon Survey provides some insights. Respondent were asked to list the reasons that motivated their most recent decisions to apply for a patent. Table 1.2 below displays the results for our sample industries.

In the aggregate, we find that preventing competitors from copying new inventions and blocking rival patents on related innovations are the leading motives for patenting, with 96% and 82% of all firms in the sample reporting these as reasons for patenting recent inventions. Prevention of infringement suits is next, after which comes the use of patents as bargaining chips in cross-licensing negotiations. Using patents as a source of licensing revenue is the least cited motive, suggesting that only a minority of firms expect to sell their protected IP in disembodied form.

Looking across industries we find a few noteworthy distinctions. Firms in chemicals, medical equipment and pharmaceuticals patent chiefly to block rivals and protect their products from imitation. Firms in the communications equipment and computer industry overwhelmingly patent to maintain their freedom to design and commercialize new products and services. They do this by preventing infringement suits and accumulating a patent portfolio to use in cross-licensing negotiations. To varying degrees, this is also true of firms in the semiconductor,

Table 1.2 Strategic reasons why firms patent

Industry	Licensing Revenue	For Use in Negots.	Prevent Suits	Prevent Copying	Blocking
Aerospace	57	59	68	97	70
Automotives	38	75	63	100	38
Chemicals	36	34	57	100	86
Communications Equipment	47	79	74	84	79
Computers	**30**	**80**	**90**	**85**	**65**
Electronic Components	33	58	75	92	75
General Purpose Machinery	13	33	50	98	80
Medical Equipment	22	58	65	95	93
Pharmaceuticals	44	61	67	100	97
Semiconductors	42	67	67	92	75
ALL manufacturing firms	**28%**	**47%**	**59%**	**96%**	**82%**

Automotive, aerospace and electronic component industries.

One way to interpret these results, and those discussed above, is to consider whether the differences among the appropriation strategies might reflect underlying differences among industries and technologies. The authors of the survey suggest, and much additional economic research confirms, that a key distinction lies in the differences between the way technical advances proceed in industries where the major technologies are complex systems, and industries where technologies are comparatively simple and discrete. We elaborate briefly on these distinctions, drawing on the work of Merges and Nelson, whose historical studies of technical advance have shed much light on innovation in different industries.[19]

Merges and Nelson find that inventions in many industries can be described as standalone products. These comparatively simple technologies can be found in industries where chemical composition is a central aspect of design such as pharmaceuticals, in the consumer and packaged goods industry, and in industries producing rather simple devices such as power tools. Innovation in discrete product industries tends to be markedly different from the kind of product development we observe in complex/cumulative invention industries. As Merges and Nelson observe, "On the input side, discrete inventions typically do not incorporate a large number of interrelated components; they stand more or less alone. On the output side, the products of discrete technology industries tend not to comprise an integral component of a larger product or system; they therefore do not enable the development of a wide array of ancillary products."[20]

Complex systems technologies have two features that differentiate them from discrete technologies.

First, a useful end product typically comprises many different components, each of which may be invented independently. Second, evolution of technology is typically cumulative or sequential in the sense that today's advances build on and interact with many features or components of existing technology. The core technologies developed in the aerospace, automotive, computers, defense and semiconductor industries all have features that one would attribute to cumulative systems technologies.

With respect to the strategic use of patents, the key difference between cumulative and discrete invention industries boils down to whether a new product or process comprises numerous patentable elements versus relatively few. New drugs and chemicals, for example, typically comprise a relatively discrete number of patentable elements, reflecting the nature of technical advance in these industries. This feature of the underlying technology enables firms to acquire enough patents to afford a level of exclusivity that is sufficient to capture monopoly rents through commercialization or licensing.

In contrast, computer hardware, software and semiconductor products, for example, tend to comprise a large number—often hundreds—of patentable elements. In such cases, firms rarely gain proprietary control over all of the essential complementary components of many of the new products they are bringing to market. Firms hold rights over technologies that others need, and vice versa, creating a condition of mutual dependence where no firm can move ahead with developing and commercializing a new technology without first gaining access to complementary technology. In such cases, a firm holding a patent on one essential element can use the threat of blocking others from commercializing their products to extract hefty licensing fees or to gain access to rival technology on favorable terms. But, since the threat of "hold-up" is often mutual, this scenario tends to result in extensive cross-licensing of intellectual property rather than a breakdown in commercialization.

Honeywell competes in both discrete and cumulative invention industries. Gary Zanfagna, Associate General Counsel for Honeywell, remarks that:

> "The value of a patent in [chemical and pharmaceutical] industries is often the exclusive right to a particular chemical or a particular blend or to a next-generation drug… The benefit is quite clear and absolute in those industries. And the level of investment in innovation is contingent on our ability to earn an expected rate of return on our investment, on the innovation we make. In others industries in which Honeywell competes, such as aerospace and home ability controls, innovation is considered more cumulative and incremental. . . Honeywell will not, and, in fact, could not patent an entire new generation engine. It patents innovations on a new engine and improvements on an engine."

This piecemeal approach to patent protection limits Honeywell's ability to exclude its competitors, but nevertheless provides them with valuable IP that they can trade in exchange for access to their rivals' complementary IP.

This explains why, in cumulative invention industries, competitive advantages are more likely to be won on the basis of closely guarded trade secrets, lead-time advantages and complementary capabilities than they are on the basis of the exclusivity conferred by a patent. Patent protection may play a secondary role, perhaps by creating a need to invent around the patent and extending the lead-time advantage for a short while. In the IT industry, for example, Daniel McCurdy observes that, "Few innovations are sufficiently fundamental to permit such exclusions. With time and money, most high-tech innovations can be engineered around. Patents are more like speed bumps than concrete barriers." Thus, with factors such as short product life cycles, the prolific practice of reverse-engineering, rising transparency and employee mobility also at play, innovation and R&D, whether protected by patents or not, never yields a complete or lengthy proprietary advantage.

The volume and accelerating rate of patenting in cumulative invention industries, on the other hand, can be explained by the constant need to strengthen one's position in cross-licensing negotiations and fend off infringement suits. In these situations, it is often not only the quality of the patents that counts. Quantity is also important, as one interviewee observed that when threatened with an infringement suit a firm will typically send "a pound or two" of copies of patents pertaining to the business of the plaintiff and suggest that it is they who are the real infringers. In this way, large patent portfolios confer reciprocal access to one another's inventions, which in turn provides the freedom of action that firms require to steadily improve and expand their product lines. These themes were prominent in all of our interviews with IT executives. We now examine those view points more thoroughly.

1.4.3 Evidence from our interviews

In the remaining analysis, we draw on our conversations with executives in software, computer hardware, telecommunications and semiconductor firms to further explore the IT industry's strategic use of patents. We were particularly interested in three questions.

a) What is the relationship between patents and innovation in the IT industry?

b) What is driving the rising propensity to patent?

c) Is the explosive growth of patents in any way inhibiting innovation in the IT industry?

There was general agreement that patents do not provide much of an incentive to innovate, or inevitably much protection of a firm's competitive advantage. As Joel Poppen, a director of patent litigation and licensing at Micron Technology put it, "If the patent system went away tomorrow, we wouldn't change our behavior." Most interviewees also agreed, however, that at a minimum patents prevent flat out copying and help deter free-riders from exploiting the R&D spending of other firms.

What drives innovation? Everyone we spoke to agreed that innovation is driven by vigorous competition and the need to stay ahead. Peter Detkin, formerly VP of Legal and Government Affairs at Intel notes that, "Intel spends three or four billion dollars a year innovating because we face fierce competition at every level from various different competitors, and if we don't do it, we're going to be knocked out of the market in a heartbeat." While Stephen Fox, Associate General Counsel at HP agrees, he also observes that, "You have to start with the premise that you have the freedom to compete. How do you get the freedom to compete; you get it through the patent system." He goes on to say that, "The concern is if you don't patent new inventions you're somehow going to lose position. So the engines have been cranked up to capture all of these inventions. And the companies that do spend a lot of money on R&D

get pretty good at it, and hence there are lots and lots of patents that are produced." This brings us to the issue of defensive patenting.

Views on the rising propensity to patent largely confirm the findings expressed in the survey results, i.e., the primary drivers of patenting are to a) defend against suits and b) gain access to industry IP on favorable terms through cross-licensing agreements. Both ultimately enhance freedom of action, something that all firms stressed was absolutely central to their ability to design and bring new products to market that respond to customer needs. Before elaborating on the contemporary role of defensive patenting, our interviewees added some nuances to our understanding of the historical transformations that set the stage for the contemporary IP landscape.

First, several interviewees highlighted the importance of recent changes in the nature of technology and the structure of the IT industry. One interviewee reminded us that the structure of the IT industry has evolved dramatically since the days where a few dominant firms created mainframe computers for which they developed and owned all of the constituent parts and standards, including the software. In those days, there was less need to cross-license because firms already owned all of the required IP to deliver a complete solution to their clients. Today we have a highly disaggregated industry in which the many hardware and software components that need to be combined to create integrated systems/solutions are developed by numerous companies. This has increased the degree to which firms are mutually dependent on a shared infrastructure and overlapping IP rights. This increases the need for firms to license technologies from each other.

Second, several individuals alluded to the fact that the strategic value of patents is being amplified by the unbundling of patents from products to constitute a distinct, and potentially lucrative, revenue stream, and in many respects, an industry in itself. Harry Wolin, VP of Intellectual Property at Advanced Micro Devices, notes that, "If you look back to the mid-1980s . . . there was a lot of freedom of action and everybody just competed and it was the same group of players. After that you see a lot of growth and a lot of new companies coming in. And I think the focus turned more from making a reasonable amount of money and moving forward with your business to a new group of CFOs coming in saying 'I'm going to make money off every asset I have.' Patents became one more asset that we had to generate revenue from." Wolin also remarked on the effectiveness of Texas Instruments' use of aggressive patent licensing in the mid-1980s as a strategy to rescue the company from vigorous competition from Japanese semiconductor firms. During his time at Motorola, Wolin was responsible for licensing patents for what he described as relatively cheap rates. "But then," as he put it, "we saw the kind of money that TI was getting for theirs and it was like, 'Hey, what are we leaving on the table here?'"

Thus, underlying shifts in technology, industry structure and licensing strategies gave birth to a new, more aggressive, approach to intellectual property strategies in the IT industry. While factors such as limiting free-riding continue to play a role, today's concerns seem to be primarily linked to litigation and cross-licensing negotiations. Stephen Fox of HP, for example, substantiates the "dual use" approach to patents that many firms employ. "We seek patent protection for our inventions both to prevent rivals from free-riding on our investments and to counter or minimize exposure to other firms' blocking patents and hold-up strategies. Our patent portfolio enables us to pursue a variety of policies to protect our inventions, from appropriately aggressive prosecution of infringing uses to licensing and cross-licensing arrangements that remove patent clouds and ensure design freedom for further initiatives."

Interviewees expressed unanimous concern about the rising costs and risks of patent litigation and hold-up in the IT industry, citing these as primary reasons for the accelerated rate of patenting.[21] Robert Kohn, now Vice Chairman of Borland, expressed the prevailing view among IT firms that the best defense against hold-up and infringements suits is a good offence. "Most of the patents filed, I would argue, in our field, in the software area, are filed for defensive purposes so that if you get sued you'll have a war chest in order to defend yourself, which is precisely what Borland did over the period of time when I was General Counsel. We filed patents on virtually everything. Any innovation in user interface design, flyover help, spreadsheet notebooks—I mean, you name it, I had my guys file patent applications."

In a context where the risks of litigation are escalating, interviewees agreed that large patent portfolios help prevent suits or hold-up problems by creating a credible threat of a counter suit. Since patents so frequently overlap, most firms in the IT industry are constantly at risk of infringing someone else's IP. As long as the risks are balanced, however, major patent owners can continue to use their own technologies in the products and services without being held-up by rival patents or infringement suits since most of the major players know that any legal move ends in a stalemate. Our interviewees commonly referred to this as a state of "mutually assured destruction." But, as Dick Thurston of Taiwan Semiconductor Manufacturing explains, it requires firms to undertake a great deal of competitive intelligence. "We do a competitive analysis of what our competitors are up to in this area . . . We want to know what potential claimants are doing and who might come after us for infringement."[22]

Our interviews also confirm the notion that the increasing rate at which firms patent is directly linked to the need to gain access to a thicket of intellectual property rights that are routinely combined in developing products and services in the IT industry. Joel Poppen at Micron Technology estimates that hundreds, if not thousands, of patents cover a typical microprocessor product. We found the same estimates hold for most products in the IT industry, not only for complex circuitry, but also for software products where patents protect unique elements of functionality as opposed to entire programs. These patent rights are typically dispersed among many different firms, making it necessary to negotiate multiple deals to move ahead with a single new product. As a result, observed one executive of a communications equipment firm, "Your patents are mostly used in horse trading. You come together and say 'here's our portfolio.' In our industry, things all build on each other. We overlap on each other's patents. Eventually we come to some agreement: 'you can use ours and we can use yours.'"

There was general agreement that it is possible to reach a successful cross-licensing agreement in a large percentage of cases where firms are mutually dependent on access to each other's IP. Dan McCurdy explains how a typical negotiation unfolds:

> "You take a portfolio, you dissect the portfolio down to relatively small number of patents . . . In general, only about one to two percent of an entire portfolio is used in an active patent assertion or patent licensing program. In the case of Lucent, we have 28,000 worldwide patents, almost 12,000 U.S. patents, and we ran a half a billion dollar licensing program by having selected 200 of those patents as those most likely to be used throughout the industry…Once you do that, you figure out who's infringing… You put together a proof with respect to that. You approach the individual and say, 'We think that we have something that you might have some interest in.' That's the code word for 'we think you're infringing.' There's a discussion that ensues. The process takes one-and-a-half to two years on average where you have given them some patents to look at. The next meeting they give you some patents to look at. . . You say in the end, 'Look we think that at "X" royalty rate you owe us $40 million a year.' They'll say, 'Well, at an equivalent rate on our patents, your products are worth $30 million a year.' You have a $10 million differential and you settle for something less than that and try to get a settlement without having to sue each other."

Cross-licensing arrangements such as these have a long history, reaching back to the early days of industries such as radio, automobiles and aircraft. But the practice appears to have become even more routine today, as most major players in the IT industry now cross-license their portfolios. Peter Detkin explains that there is an unavoidable overlap of IP in the semiconductor industry. "There's only a certain amount of ways that you can connect transistors together in new, unique and non-obvious ways, and people are tripping over each other's patents right and left." The consequence of Moore's law, he adds, is that "You're going to be tripping on a lot more patents tomorrow."

The inability to judge which patents will be important in future cross-licensing negotiations provides a significant incentive to patent as prolifically as many IT firms do. As Peter Detkin observes, "Even a firm with an extraordinarily active licensing program doesn't cite more than 15 of their patents in either licensing or litigation in any one year. The problem is you have no idea which 15 are going to be the most important ones five years from now ... So you have to try and do your best to figure out which are going to be the most valuable patents. But, at the end of the day you end up filing 5,000 patent applications a year around the world. It's a constant balancing of where the products are going to be made, who's going to be making them, who's going to be selling them."

Indeed, if patents were used merely to prevent copying, as they are in pharmaceutical and medical devices, it would be unnecessary to patent at the rate that IT firms do. As Robert Barr of Cisco explains, "We don't need to file this many patents to deter copying, we would need maybe one, two or three patents for each product . . . Instead, since our purpose is to create a portfolio for cross-licensing, we find it necessary to stockpile patents and contribute to a backlog in the Patent Office that has reached three–four years in our technology area. In an industry where healthy competition makes time-to-market critical, and the pace of innovation is so rapid, that's a long time to wait for a patent."

Cisco's entry into the patent portfolio race is informative. Between 1984 and 1993, (Cisco's first ten years in business), the company filed only one patent. By 1994 the company had grown to over $1B in annual revenue. Clearly, this growth was not fuelled by patents, but rather by aggressive competition and breakthrough innovations built on open non-proprietary network interfaces. In 1994, the company was forced to adapt to an increasingly hostile IP environment. Cisco started a program to obtain more patents for defensive reasons, citing the fact that it needed patents to maintain design freedom and to "Have something to offer in cross-licenses with mature companies that already had large patent portfolios…" Cisco filed six patents in 1994, and steadily increased that number each year since. Cisco now files more than 750 patents a year.

We found that there is less agreement and more ambiguity surrounding the immediate and long-term impacts of the strategic use of patents on innovation in the IT industry. Robert Barr's reflections on Cisco's experience sums up the more skeptical sentiments expressed in several interviews with executives at IT firms:

> "My observation is that patents have not been a positive force in stimulating innovation at Cisco. Competition has been the motivator; bringing new products to market in a timely manner is critical. Everything we have done to create new products would have been done even if we could not obtain patents on the innovations and inventions contained in these products . . . The only practical response to this problem of unintentional and sometimes unavoidable patent infringement is to file hundreds of patents each year ourselves, so that we can have something to bring to the table in cross-licensing negotiations . . . The time and money we spend on patent filings, prosecution and maintenance, litigation and licensing could be better spent on product development and research leading to more innovation. But we are filing hundreds of patents each year for reasons unrelated to promoting or protecting innovation."

While Barr's remarks capture some of the general sentiments, four key concerns were raised repeatedly by IT executives.

- **Transaction costs**. Many interviewees expressed concern about the fact that all firms must now assume the costly overhead associated with defensive patenting. Fox of HP remarked that, "It is without a doubt a serious drag on the technological and scientific progress that the patent system was designed to promote. An unknown but undoubtedly significant number of invalid patents are issued every year; an unknown but undoubtedly significant number of patents generate lawsuits or threatened lawsuits involving overly broad claims. Both phenomena create serious impediments to competition, both from existing products on the market and from new products in the development stage. Litigation has become a poor means of addressing these problems, in part because of the unacceptably high cost and length of the litigation process and in part because of the … unpredictability of litigation outcomes." The general concern here is that the accumulated transaction costs of coping with litigation and negotiating and enforcing licensing agreements with all of the relevant patent holders could significantly raise the cost of commercializing new technologies.
- **Royalty-stacking.** Another closely related concern is what is known as royalty-stacking, wherein the accumulated royalties on new products that combine patented technologies can increase prices and adversely affect the profitability of new products and services. Joel Poppen of Micron observes that as the hold-up model becomes more successful, "There's

more and more stacking of royalties on top of new products and technologies . . . Eventually those hold-up costs are going to be passed along to consumers in the form of higher prices.” In the biotech and pharmaceutical industries, where a non-exclusive license to a “must have” technology averages between 1–4% of net sales and an exclusive license averages between 6–10%, royalties can easily stack-up to 20% of net sales.

While the costs have not been quantified for the IT and software industry, some interviewees estimate that they could be equally, if not more substantial. James Pooley, a lawyer in Palo Alto, who has represented many software firms, observes that, “In the software industry we have a kind of business that’s easy to enter, but where you enter with an overwhelming sense of dread because you don’t know how many pieces of IP you will need to operate . . . And there’s also the problem that we don’t know how much we’re going to have to pay. And it can seem overwhelming when someone knocks on your door and asks for five percent of your revenue and you negotiate that, end up paying three, and then surprise, there’s someone else who asks for another five or ten percent.” Pooley notes that in many instances, the size of the claim is measured by what could happen in the litigation process, rather than by a considered view of the total costs of licensing of all the IP required to commercialize a new product. As a result, says Pooley “you end up with more than a hundred points in the percentage scheme, and that just eats up profit margins and discourages people from pursuing business.”

Most interviewees agreed that, at the very least, higher transaction costs and royalty-stacking create a tax on innovation. Few however, accepted the more extreme argument that transactional problems are creating a tragedy of the anti-commons where valuable intellectual property resources are underutilized because too many patent holders hold overlapping rights to exclude others. In such cases, transaction costs and royalties may accumulate to a point where pursuing commercialization is no longer viable. To some extent, this problem is mitigated by the fact that everyone loses—both the licensee and licensors—if transaction costs and royalties exceed the net benefits of commercialization. Indeed, we do not know of a project that has been dropped due to royalty-stacking alone. But, there is concern about the future. As Detkin put it, “At some level we’re going to have to worry about the half a million patents owned by more than 40,000 parties, and we have to worry about how we’re going to negotiate with them. Some of them don’t want to negotiate with us. I know how to negotiate with other contributors in the field, but there are some out there who say, ‘I just want billions of dollars.’”

- **Trolls**. By far the greatest source of consternation among the firms we talked to is what many in the industry refer to as “trolls” or “patent terrorists” who acquire patents (often from bankrupt IT firms) with the explicit purpose of prosecuting infringement suits against large firms that are vulnerable to hold-up problems. Robert Barr of Cisco explains that, “Obtaining patents has become for many people and companies an end in itself, not to protect an investment in research and development, not to license technology to others who need it, but to generate revenue by 'holding-up' other companies that actually make and sell products without even being aware of their patents. They try to patent things that other people or companies will unintentionally infringe and then they wait for those companies to successfully bring products to the marketplace. They place mines in the minefield. The people and companies—I am not just talking about individuals here—who file these patents and extract license fees from successful businesses play the patent system like a lottery." The problem for many firms is that stockpiling patents does not really solve the problem posed by trolls. Trolls do not actually make any products that would infringe on other firms' patents. As a result, explains Peter Denkin, "These guys have no threat of counterclaim. It's the ultimate asymmetry of risk. They're demanding billions of dollars in damages against me, and even better, they demand an injunction, which boggles my mind. . . . [In the end], they only need a few patents to put a large amount of revenue at risk." As a result, firms routinely face situations where, as Poppen puts it, "You either pay, or you potentially put your entire business at risk."

- **Fear, uncertainty and doubt (FUD).** Finally, given all the issues we outlined above, the existing situation amplifies the uncertainty that already surrounds risky R&D investment decisions in high-tech industries. As Stephen Fox of HP put it, "We have witnessed in recent years a vast proliferation of patent grants by a seriously understaffed PTO and an equally vast proliferation of complex litigation over patent validity and scope. Notwithstanding the centralization of patent law development in the Federal Circuit over the past two decades, the governing standards for patentability and patent law jurisprudence generally remain plagued by unpredictability in their application, particularly with respect to patents bearing on new or emerging technologies. The result is pervasive uncertainty about legal rights, both in terms of the ability to enforce one's own patents and the ability to avoid rapidly escalating exposures to infringement claims by others. And that uncertainty heightens risks surrounding innovation investment decisions."

Jordan Greenhall, CEO of DivXNetworks, specifically laments what he calls patent FUD—a lack of transparency or lucidity in the patent landscape created by "patent farms" that generate thousands of new patents every year. "As a small company, one of the biggest risks I face is uncertainty in the marketplace. I can minimize my risk by understanding my competitor's products very well, by understanding my products very well, by understanding what the customers want. But I've found in the past year that I really can't understand the patent landscape and that I'm sitting with a nuclear bomb on top of my products that could go off at any point and cause me simply not to have a business anymore." In the end, notes Greenhall, "I have now issued a directive that we reallocate roughly 20 to 35 percent of our developer's resources and sign on two separate law firms to increase our patent portfolio to be able to engage in the patent spew conflict… These patents are not created to protect innovation, but simply ride on the back of innovation to create a zone of obscurity where other companies really don't know what the patent landscape is."

Not all high-tech firms, however, see the new landscape in such unfavorable light. Fred Telecky, SVP and General Patent Counsel for Texas Instruments, for example, agreed that patents have fuelled an increasing number of infringement suits in the semiconductor industry. He also agreed that patents are more instrumental for cross-licensing processes than they are for protecting discrete inventions. But, Telecky sees little evidence of a systemic breakdown in competition or commercialization opportunities. If anything, he asserts that the accumulation of patents is simply evidence of successful commercialization and competition. As Telecky put it, "Companies often file patent applications for new products they plan to market, so that "patent thickets" in many instances are indicators of areas of concentration where many products exist or are planned." Furthermore, Telecky argues that in the few instances where negotiations do break down, there is an extra incentive to design around the patent thicket and create new technologies as a result.

1.4.4 Tentative conclusions on the patent thicket problem

Ultimately, these observations from leading innovators suggest that we need to take a closer look at the aggregate costs of defensive patenting to the IT industry and its customers. On one hand, it is hard to argue that there has not been an impressive amount of innovation in the IT industry over the past two decades. Any assertion that a patent thicket has fundamentally throttled the ability of IT firms to innovate certainly does not fit the facts. Moreover, there is widespread agreement among innovators that patents are a useful deterrent against copying, at least in the short-term. We also know that in the absence of property rights, it would be much more difficult and costly for firms to exchange their technologies as they do now through licensing and cross-licensing programs. Indeed, without patents there would be a much greater incentive for firms to keep their new inventions secret (as hard as this would be in many circumstances). This, in itself, would be a much more disastrous outcome as far as innovation is concerned than the present scenario in which we have a surplus of defensive patenting.

On the other hand, it is very hard to make the case that a recent rash of defensive patenting is adding much value to the IT industry and its customers, or contributing to innovation in any substantial way. On the contrary, it seems reasonable to assume that the added costs that defensive patenting imposes on commercialization and innovation are already high, and could turn out to be quite significant in the long-run if we do nothing to mitigate the problems. Recent trends indicate that costs of incessant hold-up, pervasive uncertainty, protracted negotiations and mounting royalties will accumulate as the number of patents and patentees continues to grow. As they do, it is hard to imagine how the cumulative deadweight burden of litigation and cross-licensing could not be a substantial drag on innovation.[23]

As it stands today, the situation has many characteristics of a non-cooperative strategic game in which rational players find it next to impossible to reach optimal outcomes.[24] When viewed from the perspective of one firm, it seems entirely rational, if not essential to increase and aggressively assert one's stock of patents. But, viewed collectively from the perspective of the entire industry, and society more broadly, the aggregate result of aggressive patent strategies can lead to sub-optimal outcomes for all.

In the simple one-shot game represented in Figure 19 we depict the strategy choices of two rival oligopolists that compete in a market for widgets, each of which risks infringing on the IP of its rival. Each player may either choose to add more patents to their growing patent portfolio (thereby strengthening its deterrent against litigation) or choose not to patent (thereby exposing itself to a unilateral risk of hold-up). Patenting by both firms leads to lower net profits because both bear the burden of the costly overhead associated with defensive patenting. Indeed, both firms would be better off if they could agree not to patent, or better still, to refrain from litigating. Both firms also realize, however, that its rival will be sorely tempted to cheat on such an agreement, and might unilaterally seek to strengthen its bargaining position instead. In the end, the dominant strategy is clear: each of the two firms is led to contribute to their patent portfolio, and as each does so, they both do worse than if they had signed a binding agreement or could otherwise restrict the practice of defensive patenting.

Figure 19 Game-theoretic representation of a patent portfolio race

		Firm B	
		Patent	**Don’t Patent**
Firm A	**Patent**	-5, -5	10, -10
	Don’t Patent	-10, 10	0, 0

It is easy to see that with repeated play and only two players, both firms would eventually arrive at a cooperative solution to the problem. Indeed, we observe that in practice the cooperative solution entails a cross-licensing program in which each firm develops its widgets without fear of litigation. But how long can the equilibrium hold? How many players and how many patents before the cross-licensing equilibrium breaks down?

We observe the cross-licensing equilibrium that has been sustained up to this point has been successful for two main reasons. The first reason is that, until recently, the community of major players engaging in cross-licensing programs in the IT industry was relatively small and familiar. Almost everybody made roughly equivalent contributions to advancing the state of the art. And, as Daniel McCurdy observes, in a cross-licensing negotiation, firms “Like the fact that they are dealing with someone who is a significant innovator and will continue to innovate.” The second reason is that the threat of mutually assured destruction has been roughly symmetrical among the firms who engage in cross-licensing, and, much like the Cold War, this symmetrical threat helps maintain a balanced equilibrium in the industry.

Today, we find that firms increasingly have to deal with heterogeneity along both dimensions. They not only bargain with many more players, but with multiple types of players as well. The risks are not always symmetrical and the players are not as familiar. With increasing heterogeneity comes an increasing level of uncertainty and a heightened risk that bargaining will break down, triggering a growing spew of litigation.

In addition, we observe that patent thickets can pose problems in less obvious, but equally important ways. By using patents to restrict the use of intellectual property we potentially increase the concentration of knowledge and reduce the division of labour in the economy. Particularly broad patents granted at the early stages of research and development not only have the potential to decrease the pool of potential innovators, but can also limit the range of follow-on inventions and hold back useful improvements. Reducing the scope for cumulative innovation in this way is particularly unwise when rapid technology evolution and market growth are key imperatives.

We also observe that the imperative to amass large patent portfolios and assert ever-greater control over intellectual property clashes with an equally, if not more, pressing imperative to foster a range of alternative knowledge production paradigms. For instance, all firms stand to benefit if the industry adopts a set of open standards and shared infrastructure that will ensure that complementary products work together. Open source and other models of peer production present promising ways for firms in the IT industry to enhance the scale and productivity of their innovation programs. Open science and a rich domain of IP in the public domain provide a robust foundation of knowledge upon which future inventions will build. We risk crowding out these alternative approaches to innovation and IP development with a model that privileges proprietary control above all else.

The upshot is the need for firms to carefully manage an innovation commons—a domain of technological and intellectual interdependence where rapid technological progress depends upon the ability of firms to adopt shared strategies for managing intellectual property. The instinctive public policy remedy is to weaken patent rights. Although this could partially reduce the transaction cost problem, it would further weaken the incentives for innovation.[25]

A better option is to harness market-mechanisms and industry alliances to reduce transaction costs in specific markets, while avoiding the incentive problems of weaker intellectual property rights. Our preliminary research suggests that where collective action problems can be resolved, industry institutions can provide context-specific assistance in addressing specific innovation problems.

1.5 Key lessons from our empirical review of the patent explosion

Our empirical review of the patent explosion supports three broad conclusions:

1. A combination of economic, technological, and legal changes have ushered in an era of stronger and more valuable intellectual property rights. These changes have been accompanied by a significant surge in the rate of patent applications and grants in the major centers of the global economy.
2. A vastly disproportionate share of patent growth can be attributed to information technologies, and particularly to firms within the IT industry that not only patent in their own sector, but patent in other sectors as well. We find that the propensity to patent in certain segments of the IT industry is up to 4 times higher than the propensity to patent comparable high-tech industries where the competitive pressures to innovate are equally great.
3. There is an apparent paradox in the rising patent propensities we observe in the IT industry, where the gap between the relative effectiveness of patents and their widespread use is particularly striking. We find, however,

that the paradox can be explained by a shift in the use of patents from a mechanism for appropriating the returns from innovation to a mechanism for increasing technological opportunities. But, while firms with large patent portfolios can fend off infringement suits and enter into cross-licensing arrangements that enhance their freedom of action, these strategies come at a cost.

These conclusions point to a fourth unanticipated outcome. Under certain circumstances patents do more to reduce innovation and inhibit the pace of technological progress than they do to encourage it. The tremendous growth both in the number of patents and the number of players seeking to assert them is raising the cost of commercializing new products and technologies and limiting the very freedom of action that IT firms have been urgently trying to promote.

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Endnotes

[1] OECD. 2004. Compendium of Patent Statistics.

[2] Knowledge-intensive industries account for roughly 70% of GDP in OECD countries, while intangible assets account for between 50 to 75% of the market value of all publicly traded firms in the U.S. See, Baruch Lev. 2003. "Remarks on the Measurement, Valuation, and Reporting of Intangible Assets." *FRBNY Economic Policy Review*, September 2003.

[3] Robert Merges. 1997. *Patent Law and Policy: Cases and Materials, 2nd edition*. Charlottesville: The Michie Company.

[4] Gerald Sobel. 1988. "The Courts of Appeals of the Federal Circuit: A Fifth Anniversary Look at Its Impact on Patent Law and Litigation." *The American University Law Review*. Vol 37: 1087–1139.

[5] The development of international trade law and the World Trade Organization provided yet another avenue for both harmonizing and increasing the global enforceability of intellectual property rights through the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs). Trade law is important in so far as it extends and vastly strengthens earlier efforts of U.S. government and industry officials to stamp out piracy and other IP violations by making IP enforcement a condition of gaining access to the club of WTO members. Indeed, Microsoft just recently announced that Asian governments using Linux, many of whom are prospective members of the WTO, can expect to be sued for IP violations. Steve Ballmer alleged that Linux violates some 228 software patents and was quoted as saying "someday, for all countries that are entering the WTO (World Trade Organization), somebody will come and look for money owing to the rights for that intellectual property." See, http://www.theregister.co.uk/2004/11/18/ballmer_linux_lawsuits/

[6] Numerous patents had been granted on living organisms before, particularly for new plant varieties that had been cultivated by plant breeders. In the 1970s, Boyer and Cohen patented recombinant DNA technologies: a discovery that revolutionized microbiology and is also considered to have had a significant impact on patent law. None of these previous precedents, however, had established the patentability of living organisms.

[7] In 1992, Computer Associates vs. Altai made it difficult to obtain copyright protection for structural features of computer programs; in 1994, the court refused to protect Apple's graphical user interface from

appropriation by Microsoft; and in 1995, the court ruled against copyright protection for pull-down menus in the Lotus Development Corp. vs. Borland International Inc. case.

[8] We have adopted the World Intellectual Property Organization's categorization of IT patents as those patents in the broad technology classes of computers and office equipment, telecommunications, microelectronics (including semiconductors), and consumer electronics as specified in the 7th edition of the International Patent Classification. We chose this classification in part because it enhances comparability with the statistics collected by the OECD and other national and international bodies. Unfortunately, software patents do not have a distinct category (although pure business method patents do), but many software-related patents can be found within each of the four sub-classes of IT patents. We discuss software patents at length below.

[9] OECD. 2004. *Patents and Innovation: Trends and Policy Challenges*. Paris: OECD Publications.

[10] The differences between these estimates reflect the vagueness attached to the definition of software patents and the different search strategies used by the authors.

[11] These figures are not surprising if we consider both the changing legal treatment of software patents and the broader strategic shift in the IT industry towards business services and software offerings.

[12] Of course, many of the earlier patents will have by now expired, and many recent patents in this category may not have a great deal of commercial or technological significance, suggesting that the number of truly valuable patents in the IT industry is, in fact, much lower than this chart suggests. This is an important consideration, but the cumulative growth of patents nevertheless reveals an important change in the strategic behavior of IT firms and raises concerns that the accumulation of patents could hamper the pace of innovation.

[13] The key reason why the R&D spending in these industries has not increased as a proportion of spending, while increasing absolutely, is that there has been massive growth in R&D spending in the services sector, which now constitutes 34% of all R&D performed by U.S. firms.

[14] These findings should be interpreted with some caution because there is no way to precisely match R&D inputs (reported as firm-level aggregates) to patent outputs, since R&D budgets are not broken down by technology classes as patents are, and many of the large R&D performing firms will have their hands in many different classes simultaneously. An earlier in-depth study of the semiconductor industry conducted by Hall and Ziedonis, however, reaches similar conclusions about patent propensities. These authors find that the propensity to patent among semiconductor firms doubled from 0.3 to nearly 0.6 between 1982 and 1992, increasing at a average rate of 10% a year after 1986. Moreover, they find that firms that entered the industry after the passage of the Semiconductor Chip Protection Act in 1984 have a 65% higher patent propensity than incumbents. Even more striking, "fabless" design firms that entered the industry in the mid-1980s (i.e., those firms which specialize in design and contract out chip manufacturing) were five times more likely to patent than the rest of the firms in their sample. However, since the R&D spending of design firms constitutes only 15% of overall spending in the industry, Hall and Ziedonis conclude that the primary driver of the rising patent propensity is more aggressive patenting by capital-intensive manufacturers.

[15] We have yet to conduct a similar analysis of patent propensity for telecom, consumer electronics, and software firms, but we expect that we will observe similar trends there, particularly in the software industry from the mid-1990s forward.

[16] For instance, chemical firms report obtaining patents on some elements of a chemical compound, while keeping others secret in order to provide maximum protection for their proprietary chemicals.

[17] The reverse problem, observes Dick Thurston, VP and General Counsel for Taiwan Semiconductor Manufacturing Company, is that trade secrets cannot be used to defend against patent claims of other companies. Daniel McCurdy concurs, stating that, "If I keep it a trade secret then I have the countervailing problem that if somebody else discovers it and you have published it, and you're using it, the suddenly you're blocked from using a process that you, in fact, discovered."

[18] In the wider sample of 34 industries, we find that firms in the glass, metal, printing, and textiles industries also reported that complementary capabilities were central to their appropriation strategies.

[19] Robert Merges and Richard Nelson. 1994. "On limiting or encouraging rivalry in technical progress: the effect of patent scope decisions." *Journal of Economic Behavior and Organization*, 25:1–24.

[20] Robert Merges and Richard Nelson. 1994. "On limiting or encouraging rivalry in technical progress: the

effect of patent scope decisions." *Journal of Economic Behavior and Organization*, 25:1–24.

[21] Hold-up problems, which were routinely referred to by interviewees, occur when one firm or entity threatens to seek an injunction against another firm that is infringing on their patent, but only does so after the infringing firm has invested millions, if not billions, of dollars in a new product or manufacturing process, so that the firm seeking the injunction gains maximum leverage in any cross-licensing negotiations that ensue.

[22] To a lesser degree, firms also report using publications in the same way when they sense that a patent will be ineffective. By publishing part of the invention, and keeping other parts secret, the firm can maintain its freedom to commercialize new technologies without the risk of another firm patenting it, although it would then presumably need to be secure in relying heavily on its lead time advantage. Publishing does not avert all of the risks associated with accidental infringement, as some interviewees attest to.

[23] Even a fairly benign scenario in the IT industry suggests a patent thicket will increase the fixed costs of commercializing new products, limit freedom of action in cases where cross-licenses cannot be negotiated, and raise barriers to entry for firms without valuable IP portfolios to trade. A worst-case scenario suggests that a patent thicket will create so many tollbooths on the road to product development that the progress of technological advance itself is impeded. In either scenario, there are real costs and risks that an industry still recovering from four years of slow or negative growth can ill-afford. Moreover, the position of the IT industry as a chief supplier of business infrastructure to most other industries means that these costs and risks are shared with the IT industry's customers as well.

[24] One version of such a game, The Prisoner's Dilemma, is conceptualized as a non-cooperative game in which all players have perfect information. Players can't communicate, or if they can, they can't make binding commitments. Both players prefer the cooperate-cooperate outcome. Both players are also tempted, however, to defect as they gain a greater payoff if they free-ride on the contribution of the other player. Since both players assume that the other will free-ride, they both opt to defect, yielding a sub-optimal outcome. The game is said to have a dominant strategy in the sense that the player is better off choosing to defect, no matter what the other player chooses. This outcome is a Nash equilibrium because neither player has an incentive to alter their strategy independently of the strategy choice of the other.

[25] Fixing the patent system, however, is where most recent theoretical and empirical work in law and economics tends to focus. But, we fail to see how weakening or eliminating the patent system will resolve the perversities that do exist. The patent system is a blunt instrument for solving a very delicate and idiosyncratic problem. There are probably things that can be done to improve it, but tailoring it to industry-specific needs would fragment the patent system, resulting in an ambiguous and overly bureaucratic mechanism that requires constant fine-tuning. More generally, public policy efforts are often more successful when governments help industry overcome collective action problems and market failures, rather than substitute public institutions for private ones.

The Rise of the Open Networked Enterprise

Strategy Domain	Closed Corporation	Open Networked Enterprise
1. World View	National Engine – US, Japan, Europe Protectionist	Global Engine – China, India, Emergent Free Trade
2. Corporate Boundaries	Vertically-integrated Non-porous Content M&A	Focused on Core Business Web Context, Agency + Fasttrack Business Models
3. Value Innovation	Closed Innovation Do It Yourself	+ Open Innovation + Co-Creation
4. Intellectual Property	Proprietary Protected	+ Open + Shared
5. Modus Operandi	Plan and Push Hierarchical Power over ... Lumbering	Engage and Collaborate Self-organizing Power through ... Agile
6. Business Processes	Internal (Enterprise Integration) Complex Hardwired	External (Inter-enterprise Integration) Modular Reconfigurable
7. Knowledge and Human Capital	Traditional Demographics Containerized Knowledge Internal	+ Global N-Generation Collaboration + Across the B-web
8. Information Liquidity	Opaque Asynchronous Processing Traditional BI	+ Transparent Real Time Networked Intelligence
9. Relationships	Transactions Product/Services	+ Relationship Capital + Experiences
10. Technology	Proprietary Monolithic Silos Enterprise Dumb Networks	+ Standards-based Service-oriented Interoperable + Inter-enterprise Intelligent Networks

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