Patent Reform: A Mixed Blessing For the U.S. Economy?

*Robert Hunt**

At the end of the 1990s, it seems ironic to question the performance of the American patent system. Spending by industries on research and development, measured in inflation-adjusted dollars or as a percent of gross domestic product, has never been higher (Figure 1). Patenting activity in the U.S. has never been higher (Figure 2). The rate of technological advance in sectors such as drugs, computer hardware, and software is simply amazing. Yet there is evidence that devoting even more resources to R&D could further improve our standard of living.[1]

Twenty years ago, the perspective was quite different. Reacting to the most severe recession since World War II, and observing the rapid emergence of Japanese and other foreign competitors in the computer and other high technology sectors, policymakers became increasingly concerned about the technological competitiveness of American companies. There was reason for

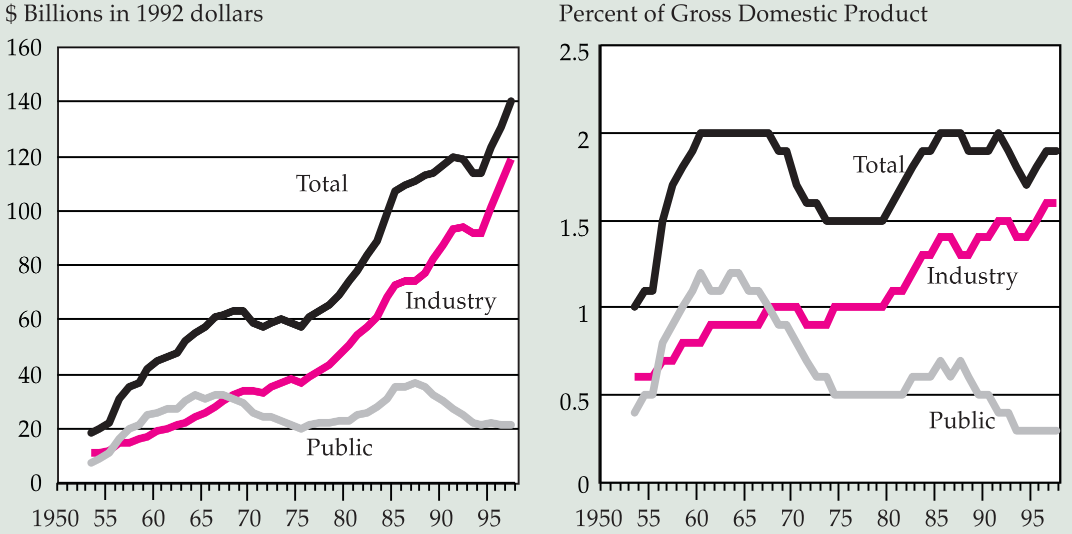
*Bob Hunt is an economist in the Research Department of the Philadelphia Fed.

[1] See, for example, the article by Charles Jones and John Williams.

FIGURE 1

Spending on Research and Development

(in dollars and as percent of GDP)



Source: Bureau of Economic Analysis: National Income and Product Accounts; National Science Foundation; and author's calculations.

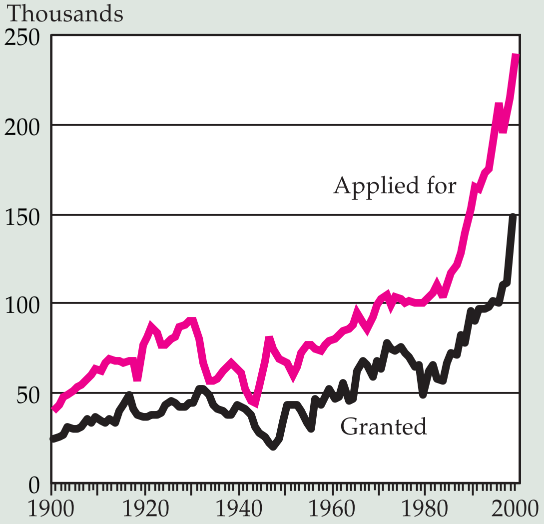
this concern. During the 1970s, private R&D spending and the number of patents issued to U.S. residents stagnated at a time when both were growing rapidly abroad. Productivity growth declined in most developed economies in the early 1970s, but it looked particularly anemic in the United States. From the late 1970s to the mid 1980s, the market share of important industries, such as steel, automobiles, and semiconductors, held by foreign companies increased dramatically.

These pressures prompted a re-examination of the American system of intellectual property law, which resulted in many significant legislative changes and important changes in the way federal courts decide patent cases. This article considers the effects of an especially important aspect of these changes: many more inventions qualify for patent protection than before. On its face, this would appear to be a good thing, since it might encourage businesses to devote additional resources to developing new products and processes. But economic analysis suggests that the effects of these changes are more complicated than they at first appear. It may well be the case that, in some industries, the rapid technological advances seen in the 1990s have occurred not *because* of these changes in patent law, but *in spite* of them.

THE NATURE OF THE U.S. PATENT SYSTEM

The U.S. Constitution grants Congress the power "to promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries."[2] Thus, the

FIGURE 2
Patent Activity



Source: U.S. Patent and Trademark Office

Constitution permits the government to offer an incentive, in the form of a temporary monopoly, to artists and inventors. Congress quickly took advantage of these powers, passing the first patent act in 1793. The act was drafted by Thomas Jefferson, who was himself a prodigious inventor.

The role of patents envisioned in our Constitution essentially follows economic intuition. It usually costs more, in terms of effort and money, to discover something new than it does to duplicate someone else's discovery. Inventors may work on their discoveries for a variety of reasons. But so long as one of the motivations is the prospect of financial reward, inventors will be concerned about the possibility that others will imitate their discoveries. If an invention can be imitated quickly, the inventor will soon be forced to compete with other suppliers, ones that did not incur the development costs he or she bore. This competition will reduce, possibly even eliminate, the profits an inventor can earn from his or her discovery. In such an environment, then, a discovery not protected by a patent gives the inventor only a fleeting advantage over his or her competitors. Obtaining a patent can reduce this competition because it gives the inventor a temporary monopoly to produce his or her invention. Thus, by helping to ensure a reasonable economic return to inventive activity, patents provide an important incentive to engage in research and development.[3]

But patents also create inefficiencies. Since patent holders have a monopoly over the patented technology, they can charge a higher price than they could charge in a competitive market. In most cases, there will be some consumers willing to buy the product at the competitive price, but unwilling to pay the higher price charged by the patent holder.

Another sort of inefficiency sometimes arises from patents. In many industries, making the best product or using the most advanced pro-

[2]U.S. Constitution, Article I, Section 8. To be precise, a patent grants the right to exclude others from producing a product or using a process covered by the patent's claims.

[3]The significance of patents as an incentive for inventors is sometimes exaggerated. Economic research verifies that patents do provide benefits to inventors, but it has also shown that other factors, such as trade secrets or simply having a head start on the competition, are often just as important. See, for example, the articles by Mark Schankerman; Richard Levin and others; and Edwin Mansfield and others.

cess may require using ideas developed by many different people. Some of those ideas will be patented, so using them requires the consent of the patent owner. While developers and users of technologies have an incentive to reach an acceptable licensing arrangement, the cost of doing so is sometimes quite high. In some cases, an acceptable arrangement is not reached and the parties may resort to litigation.

Two notable examples of this kind of failure include the airplane and the radio in the early years of the 20th century.[4] In both instances, several companies obtained patents covering important aspects of these highly valuable inventions. Unfortunately, they were unable to reach a satisfactory cross-licensing arrangement, and this failure precluded the manufacture of the most advanced aircraft or radios in the U.S. These impasses were broken by the intervention of the U.S. government during the First World War. In the case of aircraft, a successful system of cross-licensing was established, and it continued after the war. In the case of radio, patent rights were essentially suspended for the duration of the war. After the war, the U.S. Navy encouraged the formation of the Radio Corporation of America, which soon held rights to virtually all the important radio patents and a near monopoly position in the emerging industry.

To limit the effects of these kinds of inefficiencies, economists argue that patents should be granted only for novel and valuable discoveries. That is precisely what the American patent system is designed to do. To qualify for protection under U.S. patent law, an invention must be novel, useful, and nonobvious. While the first two criteria are straightforward, the third criterion is less clear. It requires that an invention represent more than a trivial advance over what is already known. This requirement, awkwardly referred to as *nonobviousness*, is typically the most difficult of the three to satisfy.

The idea that only nonobvious inventions should be patentable occurs in some of the earliest patent cases. In a famous 1851 decision, *Hotchkiss v. Greenwood*, the Supreme Court invalidated a patent on doorknobs made of porcelain or clay, arguing that the substitution of these materials for wood or metal was obvious. Thus, the judicial concept of nonobviousness was at least a century old when, in 1952, Congress amended the Patent Act to include a comparable statutory requirement.

In a 1966 case, *Graham v. Deere*, the Supreme Court described how courts should decide whether an invention satisfies the statutory requirement of nonobviousness. First, the court must determine the level of skill of an ordinary practitioner in the field. Next, it must identify the relevant knowledge that existed at the time the invention was made; this is called the prior art. The court must then identify any differences between the claimed invention and the prior art. Finally, the court must determine if those differences would have been obvious to a practitioner of ordinary skill in the relevant field. Other indicators of nonobviousness might also be considered, for example, a long-felt need for the invention, the failure of others to perfect the invention, or commercial success.

How stringent is this requirement of nonobviousness? In *Graham v. Deere*, the Supreme Court invalidated a patent on a combined sprayer and cap used on bottles of household chemicals. The cap, which covers the sprayer, protects the pump and seals off any leaks. The essential elements of the sprayer had been developed by others, but they had never been assembled in this particular way, which made possible the use of automated bottling equipment and reduced handling costs. As a result, the product was highly successful. While the Supreme Court acknowledged that long-felt need and commercial success might suggest the invention was nonobvious, in the end it decided otherwise

[4]For details on the history of these disputes, see the article by Robert Merges and Richard Nelson and the article by Paul Schaafsma.

because the differences between the product's design and that of preexisting ones were minimal.

A more recent example involves semiconductor chips used in computers and other electronic devices. In the early 1980s, courts treated the layout of most semiconductor chips in the same way they treated dress designs: unpatentable variations of a single idea—despite the fact that even minute differences in the layout of a computer chip can significantly improve its performance. In testimony before Congress, Harvard Law Professor Arthur Miller went so far as to say that "as a practical matter, the layout of a chip...will rarely, if ever, satisfy the standard of invention. A chip may be the product of millions of dollars and thousands of hours of effort, but it is the result of hard work, not 'invention.'"[5]

WHAT HAPPENED IN THE 1980s?

During the late 1970s and early 1980s, businessmen and policymakers became increasingly concerned about the apparent deterioration of America's comparative advantage in high technology industries, such as the semiconductor industry. In fact, trends within that industry became a catalyst for dramatic changes in the way the U.S. protects intellectual property.

Semiconductors were invented by American scientists in the late 1940s, and from its beginnings in the 1950s, the semiconductor manufacturing industry was dominated by American companies. The industry's growth was phenomenal. Between 1972 and 1982, the dollar value of semiconductor shipments increased more than 450 percent. If the decline in prices of computer chips during this period is taken into account, shipments in 1982 were 17 times higher than in 1972. Also, employment in the industry increased 71 percent.

So at least until the late 1970s, it would be difficult to argue that the development of the American semiconductor industry was seriously hindered by the lack of patent protection for most semiconductor designs. Indeed, some scholars argue that the industry's rapid technological development could be a consequence of limited patent protection.[6] In industries where technology is advanced by cumulative improvements, the fact that companies are able to copy many of the improvements made by rivals could be beneficial. A healthy amount of *reverse-engineering* allows a firm to incorporate the most advanced technologies, irrespective of their origin, in new designs of its own. Of course, reasonable people may disagree about what they think is a healthy amount of this kind of imitation.

Within the U.S. semiconductor industry, reverse-engineering was a well-established practice. But by the late 1970s, American firms objected to similar behavior by Japanese firms when they began to increase their market share in the more standardized products, such as computer memory chips. The level of competition eventually became so intense that, by the mid 1980s, most American companies abandoned these segments entirely.

When it became clear they could no longer dominate Japanese firms on the basis of production technology alone, American firms attempted to consolidate their comparative advantage in research and development. To do this, they would have to find ways of reducing their competitors' ability to reverse-engineer their products. To that end, American companies began to lobby Congress to increase intellectual property protection for their semiconductor designs. In 1984, Congress created a new form of intellectual property right, called *mask rights,* specially

[5]See the Senate report on S. 1201, one of the versions of the Semiconductor Chip Protection Act considered in the 98th Congress. It should be emphasized that while the layout of computer chips was generally unpatentable, new circuits or new processes for making computer chips could, and often did, qualify for patent protection.

[6]See, for example, the article by Robert Merges and Richard Nelson.

tailored to address the needs articulated by the industry.[7] A critical difference between these mask rights and patents was that the level of originality required to qualify for a mask right was substantially lower than what was implied by patent law's requirement of nonobviousness. Thus, many more semiconductor designs were likely to qualify for protection under a mask right than under a patent.

What was occurring in the semiconductor industry was also being felt in many other industries. By the late 1970s, there was considerable dissatisfaction with how federal courts were deciding patent cases, especially the frequency with which the courts were invalidating patents. In addition, there is some evidence that patents were being treated differently by federal courts in different parts of the country. This impression contributed to forum shopping by litigants, increasing the cost and delay associated with patent cases. In 1982, Congress created a new federal appeals court, the Court of Appeals for the Federal Circuit, to hear all appeals of patent cases and certain other cases.[8] It was hoped that a single court of appeals would contribute to more uniform decisions by federal district courts across the country. But the decisions of this new court also changed the way federal courts apply the test for nonobviousness.

The early decisions of this new court accomplished many things. In particular, these decisions increased the attention that courts pay to secondary factors, such as long-felt need or commercial success, when evaluating the obviousness of an invention. While these factors had long been considered by the courts, the traditional view was that secondary factors would rarely, if ever, overcome the conclusion of the multipart inquiry described earlier. For example, in one case, a federal district court considered the validity of a patent for a fastener used to attach shelves to the inside walls of refrigerators. The court concluded the invention was an obvious combination of features contained in existing fastener designs and invalidated the patent. The court refused to consider secondary considerations, in particular the product's commercial success, arguing those factors could not overcome the conclusion reached in a review of the prior art. On appeal, the new court reversed this decision, arguing that secondary factors must be considered and that, in this case, they outweighed the conclusion reached in the traditional three-step analysis. The new appeals court reached similar conclusions in a number of other decisions.[9]

It wasn't long before it was clear that the new court was deciding patent cases differently from the appeals courts that preceded it. In the first 25 years after the passage of the 1952 Patent Act, patents issued by the U.S. Patent and Trademark Office were subsequently invalidated in 60 percent of the cases decided by federal courts of appeal.[10] A 1985 study found that in a majority of patent cases reviewed by the newly created appeals court, the court determined the patent in question was nonobvious. That rate stands in contrast with the lower courts, where 30 percent of the patents reviewed were found to be

[7]Mask rights were created by the Semiconductor Chip Protection Act of 1984, 17 U.S.C. 901-914.

[8] The Federal Courts Improvement Act of 1982, 28 U.S.C 1295.

[9]For example, in a 1983 decision, *Stratoflex, Inc. v. Aeroquip Corporation,* the court stated: "Indeed, evidence of secondary considerations may often be the most probative and cogent evidence in the record. It may often establish that an invention appearing to have been obvious in light of the prior art was not."

[10]This statistic is based on an unpublished study cited in Steven Szczepanski's article. One should be careful about reading too much into statistics of this sort. Only a small fraction of all patents are involved in some form of litigation, and only a small fraction of those cases are appealed.

nonobvious. So it is hardly surprising to learn that the new court was twice as likely to reverse a lower court's finding that an invention was obvious than to reverse a finding of nonobviousness by a lower court (31 percent vs. 14 percent, respectively).[11]

What is the significance of all these decisions? About a decade after its creation, one practitioner wrote, "Many patent attorneys believe that the obviousness defense is dead and that the cause of death lies in the decisions of the Court of Appeals for the Federal Circuit."[12] Another expert argued that "as a result of these changes, patents today are more likely to be held valid than, perhaps, at any time in our history."[13]

ARE MORE PATENTS NECESSARILY BETTER?

Do these changes explain the recent surge in R&D activity and the improvement in U.S. competitiveness? Many believe that the federal circuit's decisions reduced uncertainty about the enforceability of patents, a belief that, in itself, would make them more valuable. A number of decisions increased the presumption of patent validity—that is, courts now require more evidence before concluding a patent is invalid. Other decisions made it easier for a patent holder to obtain preliminary injunctions, court orders banning a potential infringing activity before the question of infringement is definitively decided. And it does appear that centralizing the appeals process for patent cases has succeeded in reducing disparities in the treatment of patents across federal district courts.

Probably the greatest single impact of the federal circuit's decisions during the 1980s was to make patents easier to obtain by relaxing the nonobviousness requirement. Wouldn't this also encourage additional private investment in R&D? Somewhat surprisingly, the answer is unclear. In fact, it is possible that making patents easier to obtain might actually reduce R&D activity, especially in high technology industries. What explains this paradoxical result?

R&D Investments Are Related to Their Expected Return. Companies, and at least some individual inventors, make decisions about their R&D activities in the same way they make other investment decisions. In other words, they calculate how much they can expect to earn from different R&D projects and allocate their resources to the ones with the highest expected returns. The higher these expected returns are, the more a firm will be willing to invest in that project.

The expected return from an R&D project is determined by a variety of factors: the cost of the R&D, the chances of making a significant discovery, the likelihood it can be patented, and the flow of profits earned over the life of a patent. The timing of those profits matters because the sooner they are earned, the sooner they can be used to reward investors or reinvested in new projects. This means that profits earned in the near term are more valuable than profits expected to be earned far into the future.[14]

Changing Patent Law Affects the Return to R&D. Patent law matters because it affects the expected return to an R&D project in two ways: it determines the probability that a given discov-

[11]See Donald Dunner's 1985 article. These findings are re-confirmed for the 1982-94 period in Dunner's 1995 article.

[12]See Ronald Coolley's 1994 article. The title of Robert Desmond's 1993 article—"Nothing Seems Obvious to the Court of Appeals for the Federal Circuit"—is also suggestive.

[13]See Lawrence Kastriner's 1991 article.

[14]In other words, inventors discount the value of future profits to take into account the time value of money. Discounting allows inventors to compare the revenues earned in the future to dollars being spent today. The longer they must wait to earn profits on an invention, the more heavily they will discount those profits.

ery can be patented, and it also influences the flow of profits earned over the life of a patent. Relaxing patentability criteria, in particular adopting a weaker standard of nonobviousness, will have two opposing effects on the return to R&D. As patentability criteria are relaxed, a larger share of future innovations will qualify for patent protection. Firms enjoy the benefit of being able to protect more of their inventions from imitation. But firms also lose, because their ability to imitate their rivals' inventions is reduced. Each firm must now compete with rivals that, over time, will receive more patents of their own. As a result, the profits earned from a given patent tend to be smaller and may not last as long. Hence, the value of a patent declines.[15]

The question for policymakers is: which of these two effects is more important? If the probability of obtaining patent protection rises more than the value of patents declines, the expected return to R&D will increase. This should stimulate additional R&D investments and more innovation. On the other hand, if the probability of obtaining patent protection rises less than the value of patents falls, the expected return to R&D will fall. This would discourage firms from engaging in R&D, which, in turn, would reduce the rate of innovation.

Weaker Patentability Criteria and High Technology Industries. It turns out that the effect of relaxing patentability criteria on R&D activity in a given industry depends on the initial rate of innovation in that industry, which, in turn, depends on the opportunities for technological improvement and the resources devoted to perfecting those improvements. Some industries innovate more rapidly than others. In the semiconductor industry, for example, entirely new generations of computer processors and the technology to make them are developed every few years. In other industries, such as steel, it may take several decades to develop a new technology and replace an existing one.

Consider an industry that, prior to a change in the patent system, innovates slowly. In this environment, competition from new technologies takes a long time to develop, so a patentable invention is likely to be highly valuable. In such an industry, relaxing the standard of nonobviousness increases the chances that a firm will obtain a patent that is likely to generate profits for a long time. In addition, it will take a relatively long time before other firms make even the marginal discoveries that would now qualify for patent protection. So the loss of profits to this increased competition won't occur until far into the future. The effect of this increased competition on the value of patents is likely to be small, then, because profits earned far into the future are worth a lot less to the firm than profits earned today. So in the case of an industry that initially innovates slowly, the effect of an increase in the probability of obtaining a patent is probably more important than the decline in the value of patents. So a weakening of patentability criteria is likely to increase the expected return to R&D, and therefore R&D activity and the rate of innovation, in industries that initially innovate slowly.

Now consider the case of an industry that, prior to a change in the patent system, innovates more rapidly. In this environment, new technologies are invented more frequently and, if protected from imitation, very soon compete with the existing technologies. An invention in this industry generates less profits, over less time, than an invention of comparable significance in an industry that innovates more slowly. Consequently, other things equal, individual patents in this industry are less valuable. As a result,

[15]Formal models that illustrate this point include my 1999 working paper and the paper by Ted O'Donoghue and the one by Olivier Cadot and Steven Lippman. It should be noted that this research is not saying that inventions have become intrinsically less valuable. They continue to make possible better or less costly products, or both. But an increase in competition reduces the profits that can be earned on them.

firms do not stand to gain as much from an increase in the likelihood of obtaining patent protection. But once patentability criteria are relaxed, a firm's rivals are able to patent their inventions more easily, which increases their ability to become a market leader. This further reduces the value of the firm's own patents. In the case of an industry that initially innovates rapidly, the decline in patent values is likely to be more important than the increase in the probability of obtaining a patent. So a weakening of patentability criteria is more likely to *reduce* the expected return to R&D, and therefore R&D activity and the rate of innovation, in industries that initially innovate rapidly.

In sum, any positive effect on the expected return to R&D and the rate of innovation resulting from weaker patentability criteria is most likely to occur in industries that originally innovated more slowly. Any negative effect on the expected return to R&D and the rate of innovation is most likely to occur in industries that originally innovated more rapidly. Thus, relaxing the nonobviousness requirement of patent law may not be a very effective way to encourage more rapid advancement in high technology industries.

BUT WHAT ABOUT THE SURGE IN R&D ACTIVITY?

The timing of the changes in patent law, the subsequent surge in R&D activity, and the apparent improvement in American technological competitiveness convinced many attorneys and policymakers that these changes worked as intended.[16] But determining whether weaker patentability criteria really explain those improvements is a difficult empirical question. One problem with associating cause and effect is that patent law changed in so many ways during the 1980s. Outside of a few technology fields, it would be difficult to identify exactly which change in the patent system was the cause of some desirable or undesirable outcome. In addition, during the 1980s, the U.S. economy experienced very large swings in macroeconomic conditions and a dramatic restructuring of its manufacturing sector. Finally, during this same period, a large and sophisticated venture capital market emerged, significantly increasing access to capital for start-up companies in certain industries. Separating all of these influences is no easy feat.

For example, what do we make of the surge in patenting activity in the U.S. during the 1980s and 1990s? Are inventors patenting a higher share of their discoveries? Or are they making more discoveries and patenting many of those? Or is it both? One way to sort out these explanations is to look at the trend in patenting across countries. Evidence that patenting surged in the U.S., but not elsewhere, might be explained by the relaxation of patentability criteria in the 1980s. A surge of patenting in the U.S. by foreign inventors might reinforce this conclusion, especially if there was no comparable increase in patenting abroad. Conversely, a surge of patenting activity in many countries might be better explained by an increase in technological opportunities worldwide. And evidence that U.S. inventors increased their patenting abroad as much as they increased their patenting at home might be better explained by an increase in technological opportunities in the U.S.

In a recent article, economists Samuel Kortum and Josh Lerner examined trends in patenting in the U.S., Europe, and Japan. They found that European inventors increased their patenting in the U.S. in the late 1980s, but that trend was not sustained in the 1990s. Japanese inventors significantly increased their patenting activity, both at home and abroad, during the 1980s. But this is a continuation of a trend evident from the 1960s. Meanwhile, American inventors signifi-

[16]The articles by Lawrence Kastriner and Gerald Sobel are good examples of the optimistic perspective in the legal community.

cantly increased their patenting activity in the U.S. and abroad. The authors concluded these changes in aggregate patenting activity were better explained by an increase in technological opportunities in the U.S. than by a change in the treatment of patents by U.S. courts.

Kortum and Lerner also looked for evidence of a change in the value of patents during the 1980s. Unfortunately, there is not a great deal of information about the initial value of patented inventions. But there are ways to infer something about the value of patents as they get older. In the U.S. and in a number of European countries, patent owners must pay "renewal fees" to keep their patents in force the first few years after they are issued. In the U.S., patents issued after 1980 are subject to renewal fees in the fourth, eighth, and 12th years of the patent. Paying these fees is not mandatory, but if they are not paid, the patent expires at the renewal date rather than at the end of the patent's full term (20 years in the U.S.). If an owner chooses to pay a renewal fee, it is probably because he or she believes the patent remains sufficiently valuable to justify bearing the cost of the fee.[17]

Kortum and Lerner cited recent evidence that patent renewal rates fell during the first half of the 1990s, which suggests a decline in the residual value of patents.[18] This drop-off in renewal rates is consistent with the argument that making patents easier to obtain in the U.S. caused the profits earned on patents to erode more quickly. But that is only one of many possible explanations for an apparent decline in the value of patents. Since patent renewal rates have declined in other countries, perhaps other explanations may be more important.

Changes in patentability criteria could affect the rate of innovation by changing the expected return to R&D. So it may be helpful to look at more direct evidence of changes in the expected return to firms' R&D programs, for example, the stock market's valuation of R&D investments made by publicly traded companies. To derive estimates of this sort, economists use what is called the hedonic approach, which attempts to allocate a firm's stock market value to various characteristics, including its tangible and intangible assets.[19] An important component of a firm's intangible assets is its investments in R&D.[20] Investors presumably value a firm's R&D investments based on their assessment of the potential output: new technologies that contribute to the growth and profitability of the firm. The stock market's valuation of R&D investments should respond to changes in patent law that affect the profitability of developing new products and processes.

Economist Bronwyn Hall has reported that the market value of R&D investments made by

[17] The articles by Ariel Pakes and Mark Schankerman explore the relationship between patent renewal decisions and the remaining value of patents. Patent owners will always choose to renew their most valuable patents, but they may choose not to renew their less valuable ones. The profitability of different patents varies dramatically. The vast majority of patents are of little value, while a small proportion of patents are extremely valuable.

[18] Patent renewal fees increased significantly in 1990, so the authors reported changes only for years after the fees increased.

[19] This approach is described more thoroughly in Bronwyn Hall's 1999 working paper and Zvi Griliches' 1990 article and his 1984 book.

[20] In the U.S., firms' spending on research and development is expensed, i.e., deducted from revenues when calculating current profits. Some economists argue that it is more appropriate to think of R&D expenditures as an investment that contributes to a firm's stock of intangible capital. Standard accounting does not report a stock of intangible capital so this measure must be constructed using a firm's R&D expenditures and an assumption about the rate of depreciation of these investments. For details, see my 1996 working paper and Leonard Nakamura's 1999 article in the *Business Review*.

about 1000 publicly traded companies increased throughout most of the 1970s, then began to decline after 1983. The decline was especially pronounced in the electrical and computing industries, a fact Hall attributed to more rapid technological obsolescence and the competitive effects of entry by new firms.[21] Around 1990, the market's valuation of R&D investments began to rise again. Hall's findings are the result of many factors, but they provide scant support for the idea that changes in patent law increased the market value of R&D investments during the 1980s.

In previous research, I examined the market valuation of R&D investments made by a dozen American semiconductor companies from 1976 to 1994. I found that if only a firm's own R&D investments were taken into account, there was a significant increase in the market value of those investments, but that it occurred after 1989—more than five years after the significance of the changes in the patent system were widely known. While it is possible that those changes explain this increase, the long delay between the alleged cause and its effect suggests that alternative explanations cannot be ruled out.

In the semiconductor industry, the R&D activity of a company's rivals is very important. The widespread practice of reverse-engineering suggests that firms learn a great deal from each other's products, which are themselves the result of considerable research and development. That suggests the possibility of a spillover — the value of a company's own research might be affected by the research conducted by its rivals. Of course, the firm's rivals are doing the same thing, and that means they could soon be producing a similar chip that competes directly with the firm in the product market. That competition is likely to depress prices and, therefore, profits, which could reduce the market value of the firm.

In a 1996 study I analyzed three types of effects that R&D investments might have on a firm's market value: a direct effect, measured by the firm's own R&D investments; a competitive effect, measured by the R&D investments of its rivals; and a spillover effect, measured by the interaction of the firm's own R&D investments with those of its rivals. Using statistical techniques and data on a dozen American semiconductor companies, I was able to confirm that a change in the relationship between these variables and the firms' market value did occur at some point in the 1980s.[22]

In the early part of the decade, the R&D activities of its rivals tended to reduce a firm's market value (the competitive effect). During this period, the contribution to a firm's market value made by its own R&D investments (the direct effect) was quite small, but this contribution was higher the more the firm's rivals spent on R&D (a positive spillover). These results can be explained in a number of ways, but they are cer-

[21]It might at first appear that Hall's finding conflicts with the fact that private spending on R&D increased significantly during the 1980s. But a decline in the value of R&D investments amid rising R&D spending can be explained by an increase in the supply of funds available for investment in R&D projects. If the cost of funding R&D investments declined, firms would be able to invest in R&D projects that would otherwise be unprofitable.

[22]To be precise, I regressed the ratio of each firm's market to book value on a constant, the ratio of the firm's R&D capital to its physical capital, a comparable ratio for its rivals, and an interaction of these two ratios. The direct effect is captured by the coefficient on the firm's ratio of R&D capital to physical capital. That should tell us something about the value of its R&D investments relative to its investments in physical capital. The competitive effect is captured by the coefficient on the comparable ratio for the firm's rivals. That should tell us something about the extent of any loss in market value attributable to reverse-engineering by its competitors. The spillover is captured by the coefficient on the interaction of the two ratios. That should tell us something about the contribution of the firm's own reverse-engineering efforts to its market value.

tainly consistent with an environment in which firms were able to reverse-engineer improvements embodied in each other's designs and incorporate them in new designs of their own.

At some point in the late 1980s or early 1990s, circumstances began to change. R&D investments made by a firm's rivals no longer reduced its own market value (the competitive effect), and in some cases actually increased it. At the same time, a firm's own R&D investments contributed significantly more to its market value than before. In other words, the direct effect had increased. But now there was a negative spillover: R&D investments made by its rivals reduced, rather than increased, the market value of a firm's own R&D investments. These changes are consistent with a shift from an environment of significant reverse-engineering to one relying more heavily on patent protection. One interpretation of the reversal of the competitive effect is that firms shifted away from competing directly in product markets and, more often than before, were supplying state-of-the-art components for their rivals' products. One interpretation of the reversal of the spillover effect is that firms were now able to use patents to preclude rivals from developing certain technologies.

The overall effect of these changes was that, once the spillover effect is taken into account, the market value of R&D investments for this group of semiconductor companies during the late 1980s and early 1990s was either the same as or lower than it was in the early 1980s. These results do not support the idea that granting mask rights or otherwise making patents easier to obtain raised the expected return to R&D among established firms in the U.S. semiconductor industry.

Nevertheless, both private R&D spending and patent activity in the industry increased significantly during the 1980s and early 1990s. It may be that other factors were more important than changes in the treatment of patents by U.S. courts. For example, a number of scholars point out that most American manufacturers retreated from certain industry segments and concentrated on products that were less susceptible to reverse-engineering.[23] Others argue that companies adapted to changes in the patent system in ways not anticipated by supporters of those changes. For example, Bronwyn Hall and Rose Marie Ham describe what they see as a trend toward strategic patenting, in which firms try to assemble large patent portfolios in the hopes of gaining leverage in cross-licensing negotiations with their competitors.[24]

CONCLUSION

Economic intuition in itself cannot tell us whether the weaker nonobviousness requirements adopted in the 1980s resulted in less R&D activity than would have occurred without those changes. But it does show that such an outcome is possible and that it is more likely to occur in rapidly innovating industries. Consequently, these changes tend to favor traditional industries over high technology ones. If policymakers remain concerned about encouraging innovation in high technology industries, they should also be concerned about whether the changes adopted in the 1980s advanced or retarded progress toward that goal.

The relatively small amount of empirical research that has been done so far is not favorable to the view that the recent, and impressive, increases in private R&D spending and patenting can be explained by the changes in patent law that occurred in the 1980s. A great deal more research needs to be done to reach a definitive conclusion about the effects of adopting weaker patentablity criteria. But the theoretical and empirical work we have available today suggests there is good reason to exercise caution before adopting similar changes in the future.

[23]See, for example, the articles by Steven Kasch, John Rauch, and Robert Risberg.

[24]See their 1999 working paper for an examination of patenting activity within the semiconductor industry.

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Economic theory suggests that providing firms with monopoly rights via patents today will result in price increases and an inefficiently low number of pharmaceuticals sold. In exchange for this inefficiency, patents are intended to provide the necessary incentives for the development of products in the future. Many activists and policymakers have decried TRIPS, and protestations have represented fears about the outcome of a textbook product patent system, i.e. one in which foreign innovating firms are granted monopoly rights while domestic infringing firms are immediately pushed out of the mar Hunt, R. M. (1999a), Patent reform: a mixed blessing for the US economy, Business Review, Federal Bank of Philadelphia, Novemberâ€"December, 15â€"29. Hunt, R. M. (1999b), Non-Obviousness and the Incentive to Innovate: An Economic Analysis on Intellectual Property Reform, Working Paper no. 99â€"3, Federal Bank of Philadelphia. Jaffe, A. B. (2000), The U.S. patent system in transition: policy innovation and the innovation process, Research Policy, 29, 5, 531â€"557. Krastiner, L. G. (1991), The rival confidence in the patent system, International Journal of Patents and Trademarks Office Society, 73, 5â€"23 The US Patent Law today adopts both streams of thought; however, the concept of monopolies and patents, in the US, initiated with the British thought of advantages to society.[1].Â This first general patent act of the state of South Carolina is titled "An Act for the Encouragement of Arts and Sciences." Although most of its terms concerned the protection of copyrights, it also included the following provision: "The Inventors of useful machines shall have a like exclusive privilege of making or vending their machines for the like term of 14 years, under the same privileges and restrictions hereby granted to, and imposed on, the authors of books."[7][8].