INTELLECTUAL PROPERTY OFFICE

STRATEGIC ADVISORY BOARD FOR INTELLECTUAL PROPERTY POLICY

Economic Value of Intellectual Property Forum

Research Paper

The Intellectual Property Rights System and its role in Innovation and Economic Performance

Josh Lerner

Intellectual Property Office is an operating name of the Patent Office

The Intellectual Property Rights System and its role in Innovation and Economic Performance

Josh Lerner

Harvard Business School and National Bureau of Economic Research[1]

[1] I thank the United Kingdom Intellectual Property Office and Harvard Business School's Division of Research for financial support. This essay is based in part on Jaffe and Lerner [2004] and Lerner [2009]. All errors and omissions are my own.

Introduction

In the past few years, the topic of intellectual property has become increasingly controversial. Whether the subject matter is patents on bioengineered foods or financial products, or else copyright protections for songs and open source software, voices questioning the intellectual property system are increasingly being raised. Moreover, this is not a "black and white" subject matter: while economists have been studying and debating the consequences of intellectual property protection for over a century and a half, there are few easy answers.

This paper will explore what we know about this important and controversial topic .After a brief review of the arguments for and against intellectual property rights as a spur to innovation, we will turn to a review of some of the key findings in the empirical literature. We will end with some questions that should define the research agenda going forward.

Before we plunge in, several caveats should be noted. Intellectual property is a vast and complex topic, and the subject of many thousands of learned (and frequently incomprehensible!) treatises. Thus, it necessary to simply a complex topic. In particular, I will focus on patent protection, even though many similar arguments could be made relating to copyright protection. And, of course, many subtle arguments will need to be passed over quickly, or ignored entirely. Nonetheless, it is the author's hope that this treatment will be a useful one.

1. *The case for patent protection as a spur to innovation*

Economists have long argued that patents have a potential to boost innovation. Before turning to the case for this form of protection as a boost to new technological development, it may be helpful to consider a couple of examples of innovative firms that would have found it difficult to raise financing or attract employees were it not for patents.

Two examples

Qualcomm is a communications-technology company that was founded in 1985.[2] It pioneered a technology known as CDMA ("Code Division Multiple Access) that allows cell phones and other mobile communications devices to use the radio spectrum efficiently. CDMA is covered by a patent applied for by Qualcomm in 1990 and granted by the Patent Office in 1992. Qualcomm uses this technology in its own products, and has also licensed it to dozens of other companies. To get to this point, it has had to compete against large, established companies such as Motorola. It has succeeded on the strength of its technology. It is unlikely that this success could have been achieved if the CDMA technology had not been protected by patent.

[2]This paragraph is based on, among other sources, a wide variety of press releases from Qualcomm's web site; its filings with the U.S. Securities and Exchange Commission; and pres articles such as Peggy Albright, "Qualcomm Beats Patent Challenges," *Wireless Week*, (February 25, 2002) 14.

Another billion-dollar company that has grown from nowhere based on patents is Biogen.[3] Founded in 1978 by a group of scientists including two who eventually won the Nobel Prize, Biogen was among the first companies to use the new techniques of genetic engineering to develop pharmaceutical products. It raised millions of dollars, first through venture capital, and then through a public stock offering in 1983, and used this money to fund the development of new products such as alpha and beta interferon and a vaccine for hepatitis B. To finance the even greater cost of clinical trials of these products, Biogen has entered into partnerships with several of the world's pharmaceutical giants. Neither its investors nor its industry partners would have been willing to invest in these products if patents had not protected them. Indeed, for the first 15 years of its existence, Biogen never manufactured or sold any tangible "product." In effect, they "sold" the output of their research to other companies, who in turn used the Biogen technology to make products for consumers. This allowed Biogen to specialize in what it did best. Such specialization through a market for "technology" itself would not be possible without patents to protect that technology, because without patents Biogen's partners could simply go off on their own once they learned what Biogen had accomplished.

The essence of the success of companies like Qualcomm and Biogen is that they were able to use the legal protection offered by patents to document and protect their inventions. Conceptually, what patents do is convert the intangible creation of an inventor into "property" that can be bought and sold, or upon which a business can be founded.

The simple case for patents as a spur to innovation

The standard economic explanation of the impact of patents on innovation has three basic parts. First, the development and commercialization of new technologies—technological innovation—creates broad social benefits. Over time, it allows us collectively to live longer, healthier lives; to have growing monetary incomes; and to consume a broader array of goods and services. It is the primary reason why our lives look so different from those of our grandparents. It is in our collective interests to create institutions that foster technological innovation.

The next step in the argument for having patents as part of that legal environment is the recognition that the process of technological innovation is expensive. New products and services do not just spring full-grown from the creative mind of an inventor. Though an instantaneous spark of creative genius may start an innovative flame, it typically takes years of research and development to nurture that fire into a commercially viable blaze, with a lot of false alarms along the way. And that nurturing process costs money—often a lot of money.

If technological innovation is socially desirable, but is expensive, then society needs to have institutions that direct time and money into the processes of research and development. One approach to this might be to have the government use money raised through taxes to

[3]The information in this paragraph is from Biogen's filings with the U.S. Securities and Exchange Commission; a variety of analyst reports; historical material on the firm's web site; and discussions with company executives.

research and develop new technologies. In fact, the U.S. government does do a lot of R&D, particularly in areas like defense, space, and the environment that are themselves important areas of government responsibility. But in our free-enterprise system, we don't think it is a good idea to give the government the job of developing new products and processes for industry. Government is good at many things, but taking entrepreneurial initiative is not one of them.

If society wants technological innovation, but the government can't do it, then what we need are institutions that create *incentives* so that private individuals and firms will invest their own money in the process. With the occasional exception of the visionary inventor who wants to see an invention to market at all cost, the incentive to invest in R&D must come, ultimately, from an expectation of making a bunch of money if the thing pans out.

To make innovation rewarding, the government must give or grant something valuable to people or firms that produce important innovations. Under a patent system, this grant takes the form of using the government's legal system to create a zone of economic exclusivity for the innovator. A more direct approach might be to simply reward the innovator with money. In the 17th and 18th centuries the early patent system in Great Britain coexisted with the use of "prizes" to reward people who produced successful innovative solutions to particular technological problems. Some scholars of the innovation process continue to advocate the use of prizes; Michael Kremer, for example, has argued that a major prize should be offered as an inducement for drug companies to develop vaccines for tropical diseases (because those who need these vaccines are too poor to make this research profitable even with patent protection).[4]

While prizes may be an effective mechanism for drawing forth a specific, desired technology, they are not as effective a mechanism for bringing forth innovation in general. First, it would be expensive to hand out enough prizes to reward the gamut of industrial innovation; raising the tax money to do this would be both unpopular and economically burdensome. Further, it would be hard to figure out how big a prize to give to each innovation. In most cases, the importance of a discovery is initially uncertain. If the government tried to reward innovation in a general way with prizes, it would probably set too large a reward in some cases and not enough of a prize in others. For instance, a full 50,000 pounds (several millions of today's dollars) was paid by the British government to John Palmer, the inventor of a new way of organizing the mail. This was far more than that paid to Edward Jenner for his smallpox vaccine, which would be responsible for saving literally millions of lives in the years to come.[5] Patents, on the other hand, are by their nature proportional to the size of the discovery: the

[4]Michael Kremer, "Creating Markets for New Vaccines: Part I, Rationale" and "Creating Markets for New Vaccines: Part II, Design Issues," *Innovation Policy and the Economy*, 1 (2000), 35-118.

[5]The history of British prizes for invention is reviewed in depth in "Report and Minutes of Evidence Taken Before the Select Committee of the House of Lords Appointed to Consider of the Bills for the Amendment of the Law Touching Letters Patent for Inventions with Appendix and Index," *Parliamentary Papers* 1851 (486) XVIII, 1851.

exclusive right to a modest discovery is unlikely to be worth very much, while the exclusive right to an important new technology is usually very valuable. Thus, at least in principle, patents provide an appropriately calibrated reward for different innovations.

Controlling the risks inherent in innovation

This risk of imitation hangs over all investments in R&D. This can be seen most clearly, perhaps, with respect to prescription pharmaceuticals. The Food and Drug Administration (FDA) must approve drugs sold in the U.S. In order to approve a drug, the FDA requires proof, in the form of expensive clinical studies, that the drug is safe and effective. This means that *after* a chemical compound has been discovered, and its initial use for health purposes identified, someone (usually a large drug company) must spend hundreds of millions of dollars conducting tests to prove to the FDA that the drug is safe and effective. Once the drug is on the market, however, anyone with a decent chemistry lab can figure out what it's made of, and in most cases could then manufacture and sell it.

Competition from such imitators would then drive down the price of the drug. (Indeed, this is exactly what happens when the patent expires and the drug is subject to "generic" competition.) Lower prices for drugs might seem like a good thing for society, but if competition quickly reduces the price of a new drug, the company that invented the drug would not earn significant profits from selling it. And, in a world with no patents, this scenario is exactly what drug firms would expect to unfold if they developed a truly successful new drug. Now, put yourself in the lab coat of a pharmaceutical R&D director. Every time you try to bring a drug to market, you have to ask for permission to spend a couple hundred million dollars for clinical testing. If the drug turns out to be a dud—the overwhelming majority of promising new compounds never even get approved, and many of those approved have only modest sales—you lose a couple hundred million. If it turns out to be successful, you can sell a bunch of it—but in this hypothetical patent-free world, all your competitors would then jump in and sell it too, so you wouldn't really make much money selling it. Maybe you would make back part of what you spent developing it, but probably not all of it. So the game you are playing is "heads you lose big, tails you lose only a little." This is not a game that your board of directors is going to let you play for very long. And if no one plays this game, no new drugs get developed.

Thus, patents make new drugs expensive, which is bad. But if they weren't expensive, then the revenue from selling them wouldn't justify the large cost of developing them. So nobody would. And expensive new drugs are better than no new drugs. This is the tradeoff at the heart of the patent system. We grant monopolies, *knowing* that this will make the patented products more expensive, and allow some holders of patent monopolies to earn "obscene" profits: the prospect of those obscene profits is what drives firms to develop new products and processes in the first place, and the flow of revenues from one generation of successful products provides a reliable means of financing the research necessary to develop the next.

Moreover, the nature of the innovation game is such that the profits or returns to innovation are extremely skewed. Most investments in new products and processes fail, meaning that their investors lose money. A very small fraction of investments in new products

or processes succeed. For the overall "game" of investing in new technology to be worthwhile, the successes must earn enough profit to cover not only their own costs and reasonable return, but also the costs and a reasonable return on those costs for all of the failures. Otherwise, the overall investment strategy will be a loser. Suppose you (or other investors) can put their money in the bank or in treasury bills and earn a safe $5 per year for every $100 you invest. Now suppose you have the option of investing in a series of research investments. You expect that 9 out of 10 will fail, meaning that you will earn no money on those investments: you will only get back the amount you invested. About one out of 10 will "succeed."

Success, of course, comes in different magnitudes. Suppose that "success" in this case was likely to mean that you earned $20 for each $100 invested. That seems like quite a healthy return, four times as great as the safe return of treasury bills. But the problem is that you can't know in advance which of the 10 projects will succeed, and which ones will fail. On average, you have to expect that you are going to end up with 9 duds for every success. This means that on an investment of $1000 ($100 in each of 10 projects), you would expect to earn only $20 (0 on 9 of them, $20 on the one success). This gives you an average return of only $2 on each $100 invested, much worse than just leaving the money in the bank. In order to consider playing this risky "game," you have to expect that the "successful" project will in fact earn more than $50 on each $100 invested, a very high return indeed. Looked at in isolation, you might even say that this project was earning "obscene" profits. But that "obscene" level of profit is what is needed to make the overall portfolio worthy of investment.

This example actually understates the risk in many R&D investments, because it assumes that the "failures" earn a return of zero, meaning that if you invest $100, you end up with "only" $100. But many R&D investments produce large *negative* returns. That is, you may invest $100 and simply lose it all. It is easy to see that this likelihood increases even further the profit that must be earned on the "successes," if the overall return on a portfolio of investments is to be adequate. Consider, again, the pharmaceutical industry. Studies of pharmaceutical R&D estimate that if you screen five to ten thousand compounds for possible clinical use, on average 250 of these will show enough promise to be put into pre-clinical testing. Of these 250, five will show sufficient promise to enter clinical testing; the rest are simply abandoned. Clinical testing is where the really big bucks get spent, typically in excess of half a *billion* dollars per drug.[6] Of these five drugs subjected to expensive clinical testing, on average only one will be approved by the FDA. And of course, FDA approval does not ensure large profits. Many approved products have small markets. If we combine the risks of failure at the clinical trial and market stages, 80% of these expensive testing efforts are complete losers, never leading to an FDA-approved product. About 14% lead to an FDA-approved product, but do not earn sufficient profits to recoup their own development costs. Only 6% earn sufficient profits to recoup their own

[6]Joseph A. DiMasi, Ronald W. Hansen, and Henry G. Grabowski, "The Price of Innovation: New Estimates of Drug Development Costs," *Journal of Health Economics*, 22 (2003) 151–185.

investment costs, and of course this 6% must also earn sufficient profits to pay for all of the losses on the other 94% of compounds tested![7]

Generally speaking, neither the managers of firms nor investors like risk. Investments that are risky are less likely to be undertaken, all else being equal. So the high risk associated with R&D tends to discourage firms from undertaking it, even if the rewards are reasonably high. Investment in new technology is therefore handicapped by its riskiness, when compared with other forms of spending (for instance, expenditures on heavier marketing of an existing brand). Furthermore, when a business builds a new factory or buys some new equipment, it doesn't normally worry that its competitors will simply come and steal the equipment. When a business invests in R&D, it is "building" an asset that it hopes to profit from, just as it does when it builds a factory. But the asset that you build with research is intangible. Being intangible, it is much easier for other firms to steal.

This is where the patent system comes in. Your ability to patent your product or process allows you to build a security fence around your idea, analogous to the security fence that you might build around your factory. Like any fence, it won't necessarily prevent all theft, but if will make theft harder and hence make the property more secure. And the knowledge that this fence will be available if you "build" your intangible property through R&D makes you more willing to take the risk of building it to begin with.

The U.S. Constitution authorizes the Congress to establish a patent system, with the stated purpose being "[t]o promote the Progress of Science and useful Arts." This is often interpreted in terms of creating incentives for inventors. And incentives for inventors are important. As illustrated by the example of drug development, however, it is at least as important to provide incentives for the investments that must be made *after* the initial spark of invention has ignited. Patents protect an individual's or firm's investment in the development of an idea, as much as they protect the invention itself. In this, as in so many other ways, the Founding Fathers showed amazing foresight. While the U.S. was a largely agrarian and craft-based economy in the 18th century, the patent system that was built on the Constitutional foundation provided the basis for technological progress that propelled the U.S. in the 19th and 20th centuries into a position of global technological superiority.

In summary: we want investments to be made in technological innovation. We don't think it will work well to have all or most such investments made using public funds, so we need to provide incentives for private individuals and firms to make the investments. The likelihood of imitation if new products are successful makes such investments very risky, and hence in the absence of a way to protect against imitation, we worry that not enough would be spent on R&D in the private sector. Patents provide such a mechanism, although we will soon see that even the best-functioning patent system is not costless.

[7] "PhRMA Industry Profile," Pharmaceutical Research and Manufacturers of America, http://www.phrma.org/publications/publications/profile02/index.cfm.

Patents have played a role in many of the most important inventions of the last two centuries. Thomas Edison was issued thousands of patents, and the patents that he held played important roles in the commercialization of many of the inventions for which he is most famous. In many cases, of course, it is hard to know how things would have worked out if the invention could not have been patented. One case where it is clear that without patent protection the invention never would have made it to market is the photocopier, better known to many as the "Xerox" machine.[8] There are actually two distinct senses in which the patent system was responsible for this invention. Chester Carlson worked in the patent division of P.R. Mallory & Company, a small electrical components maker during the Great Depression. Part of his job was meticulously copying the text and images in patent documents—which he found exceedingly tedious. This tedium induced Carlson to try to develop a machine to do it.

There were cameras, of course, but photography was messy and expensive. Carlson set about trying to develop a dry reproduction technique, working in the kitchen of his New York apartment. In 1937 he patented the key technological idea that still underlies many copiers (and computer printers) today: using patterns of static electricity to stick tiny particles of dry ink onto a surface, and then running paper over that surface to produce an image.

But it was not until 1960 that the Haloid Xerox 914, the first commercially successful office copy machine, was introduced. The reason for this two-decade delay was that it turned out that coming up with the key technological insight into the *concept* of dry copying was not the really hard part of building a workable dry copier. The hard part was designing and building a reasonably priced, reasonably sized machine that would feed sheets of paper onto and off of the copy surface, and do it in a way that didn't generate so much random static electricity that it destroyed the process. Carlson himself spent about ten years on this. But the problems were not successfully solved until the project was taken over by a small photographic supplies company located in Rochester, New York, then called the Haloid Company. Haloid saw inadequate growth potential in their traditional businesses. Searching around for something new, they stumbled on Carlson's work, and bet the company on it. They licensed Carlson's early patents in 1946, and began spending a quarter of the company's annual net income on developing a workable office product based on Carlson's "electrophotography."

Though it took a decade and a half, this bet eventually paid off, and Haloid eventually changed its name to "Xerox" Corporation, a name coined from the Greek *xeros* ("dry") and *graphos* ("writing"). The Carlson patent had, of course, expired before success of the 914 Model allowed Xerox to make any money on the idea. Along the way, however, Haloid/Xerox had managed to patent many of the subsidiary technologies that allowed the system to function. Even with the basic patent on electrophotography long gone, Xerox had such a strong patent position in dry copying technology that it was sued in the early 1970s by the Federal Trade

[8]This account is taken from Ira Flatow, *They All Laughed… From Light Bulbs to Lasers: The Fascinating Stories Behind the Great Inventions that have Changed Our Lives*, New York: Harper Collins, 1992, Chapter 11.

Commission for monopolizing the photocopier market (which it had created), and settled the suit by agreeing to license some of its patents.[9]

You don't bet the company on a purchase that you can't "own" if it is successful. While vision, persistence, know-how and luck were all important ingredients in the long struggle to make a practical photocopier, the patents were also essential. The image of Chester Carlson toiling in the kitchen and beauty salon fits our mythology of invention. But the 15-year slog by Haloid/Xerox to get the thing to work is paradigmatic of the time and money it takes to commercialize inventors' brilliant flashes. And that simply would not have occurred without patent protection.

2. The simple case is too simple

The above explanation of the desirability of patents contains a lot of truth, but it also leaves a lot out. The things that it leaves out can be grouped into three categories of issues:

a. Companies have other methods for preventing imitation, so patents are but one of many tools in a toolkit that firms have available to protect their profits from innovation.

b. Inventions don't occur in isolation. Inventions from different firms overlap and build on each other. This means that if one firm gets a patent, it can retard or stifle inventions that other firms might otherwise undertake, thereby clouding patents' overall effect on technological progress.

c. Some firms and individuals use patents more like grenades than like security fences, threatening others' property rather than just defending their own.

Other means of protecting new products and processes

In some cases, imitation can be prevented or at least inhibited through *secrecy*. For instance, there is a safe somewhere in Atlanta in which it is said that the formula for Coca-Cola resides. This formula is not patented, but others supposedly cannot exactly duplicate Coke. Because the drink is a mixture of complex natural substances, it is not possible to duplicate it simply by analyzing the stuff. Similarly, Microsoft does not publish the source code for its Windows operating system. Even if there were not patents on components of Windows, it would be virtually impossible for a would-be imitator to create an exact duplicate of the system.[10] As a legal matter, "trade secrecy" is a distinct form of protection for intellectual property. If a

[9]The early 1970s was a time of maximal scrutiny by the governmental authorities that enforce laws regulating competition of business strategies that used patents to build broad positions of market dominance.

[10]Windows is also protected through copyright, though this largely protects only the software code itself, and not the ideas behind the program.

company makes appropriate efforts to prevent the disclosure of secret information that is valuable to its business, then an employee or competitor who somehow gets access to such a trade secret can be sued if they attempt to use it commercially. This protection is completely separate from any protection provided by patents. Secrecy can be particularly valuable in protecting new *processes* rather than new products.

Another way that firms can protect innovations even without patents is through a *first mover advantage*. In the argument above, once the competitors notice your success and come in with their copies, they are able to take away many of your customers. But because you were the one who had the innovation, you were in the market first. Sometimes, simply being first is enough to confer a lasting advantage over others. Such an advantage can come about because consumers are reluctant to switch brands once they have purchased one variety of a product and come to rely on it. Such reluctance is partly just human nature, captured in numerous clichés such as "if it ain't broke don't fix it" and "don't change horses in midstream." It also has a straightforward economic basis in those cases where it is difficult or impossible to verify the quality of a good before you purchase and use it. Having made the investment to try one brand, and learned that it works well for you, it is costly to try another, unknown brand, and take the risk that it will disappoint. First-mover advantages are often augmented by *brand loyalty*.

The ability of firms to use secrecy, a first-mover advantage, brand loyalty, and other strategies to protect their innovations means that innovation would not grind to a total halt without the protection of patents. Indeed, numerous important innovations are never patented, or are patented but the patent protection is not really important to their commercial success. This does not mean that patents are unimportant, but it does mean that their importance in maintaining the flow of new technologies varies across different industries and different kinds of firms.

Cumulative and overlapping innovation

At the same time, we generally want to encourage improvements in existing technologies. And, just as the case with "original" inventions, inventing and developing improvements is time-consuming and costly. So we need to have good incentives.

Obviously, the firm that is making and selling a given technology has an incentive to improve it. But in many cases, they may not be the ones in the best position to make such improvements. As in the broom closet example, it is often customers who have good ideas about product improvements. More generally, one of its competitors might not just imitate the new technology; they might actually figure out a way to do it even better. So how do we create *broad* incentives for people to invest in improvements?

The obvious answer is to grant patents on improvements, and such patents are indeed allowed, *if the improvement embodies some idea that was not covered by the patent on the underlying technology*. This seems fair. But in practice it is tricky to implement. To make the patent on the original invention useful, its owner must be given some latitude to modify the invention and still have it be covered by the original patent. But if such latitude is too wide, then many improvements are likely to fall under the original patent. So there is a tradeoff: granting

broad patent protection gives the maximum incentive for "original" inventions, but it may actually discourage improvements.

A classic example of the tradeoff between rewarding pioneering inventions and allowing improvements is the Edison electric light bulb. Edison was granted the basic patent on incandescent lighting in 1880. For the next dozen years or so, there was much dispute about the validity and breadth of this patent. Many companies offered competing products. A number of these contained important improvements in the design of the filament and the bulb itself, and the cost of the bulb trended steadily downward. Then, in 1891, Edison General Electric Company won an infringement suit against its competitor United States Electric Lighting,[11] and subsequently won injunctions against a number of competitors. The flow of improvements then slowed, until the expiration of the patent allowed competitors to re-enter, and resume their efforts to improve Edison's design.[12] Now, surely Edison's invention was about as novel as they get. And Edison and his assistants put a lot of time and money into testing different materials until they succeeded with the carbon filament, justifying a patent to allow significant profits to be earned on the invention. But acknowledging the legitimacy of Edison's patent and his efforts to enforce it is not inconsistent with recognizing that the monopoly thereby created temporarily inhibited the subsequent improvement of the invention and the development of the industry more broadly.

In principle, subsequent inventors with good ideas about improving an important invention ought to be able to negotiate an agreement with the owner of the original patent that allows the improvement to be implemented. This could be done by granting the improver a license to use the original patent, or by selling or licensing the improvement back to the holder of the original invention. After all, if the improvement is really a good one, both the original inventor and the improver have an incentive to see it implemented. In practice, however, such agreements often are difficult to work out. After the Wright brothers patented their basic design for an aircraft stabilization and steering system, there were many others who wanted to work on a wide variety of different ideas for aircraft. But the Wright brothers refused to license anyone, and engaged in protracted litigation with a number of designers.[13] With the entry of the United States into World War I, the U.S. government in fact pushed the major aircraft manufacturers, including the Wrights' firm, to license their patents as a package, in order to ensure the rapid manufacture of planes and the development of new designs. The rapid development of numerous different aircraft concepts in the years after the establishment of this "patent pool" suggests that the pioneering patent—combined with the unwillingness or inability of the

[11]*Edison Elec. Light Co. v. United States Elec. Lighting Co.*, 47 F. 454 (C.C.S.D.N.Y. 1891).

[12]See Arthur Bright, *The Electric-Lamp Industry: Technological Change and Economic Development from 1800 to 1947*, New York: Macmillan, 1949.

[13]See *Wright Co. v. Herring-Curtiss Co.*, 204 F. 597, 614 (W.D.N.Y. 1913), as well as the discussion in George Bittlingmayer, "Property Rights, Progress, and the Aircraft Patent Agreement," *Journal of Law and Economics*, 31 (1988) 227-248.

inventors to cooperate with their technological followers—temporarily retarded the development of technology.

Thus, there is an inherent tension between providing strong patent rights to encourage break-through innovations, and the inhibition that those strong protections may create for the development of subsequent improvements.[14] A related problem is created by the reality that firms are often working more or less in parallel on related research. Multiple firms may each apply for patents on what are, in effect, different versions of the same idea or set of ideas. In principle, what should happen is that each should be entitled to a patent only on those aspects (if any) of their creation that are unique and truly new. In practice, this is very hard to do. What is likely is that each will be granted a patent that describes its invention in a way that leaves considerable ambiguity as to whether or not the inventions of the other firms are or are not covered. As a result, all may suffer uncertainty about what products they can or can't legally sell. In the face of potentially overlapping patent grants, the risks associated with bringing new products to market are augmented rather than reduced, because expensive litigation with uncertain outcomes is added to other worries.[15] Thus the patent system in such cases may well inhibit rather than encourage innovation.

Sometimes parallel development leads to a situation where the problem is not so much uncertainty about patent rights, but patent rights that interfere with each other. In the early history of radio, the British inventor Marconi was granted a basic patent on radio transmission, and also acquired another patent on the two-element vacuum tube, or diode. (Some of us are old enough to remember when radios and TV's had "tubes.") The diode was a crucial and fundamental invention, but it was improved upon by the three-element tube or "triode" invented by Lee De Forest. AT&T held the patent on the triode. The courts ruled that the triode was an improvement on the diode, and as such AT&T and De Forest could not use the triode without a license to the diode patent controlled by Marconi. Marconi refused to grant such a license, but of course he could not, himself, make triodes without a license from AT&T, which was not granted. As a result, the triode, which was widely seen as a major improvement, was simply not used for some time.[16] So again we see a situation where patent rights retard the improvement of technology, and do so despite the incentive faced by the parties to use license agreements to solve the problem.

---

[14]These issues have been explored in a series of papers by Suzanne Scotchmer and her co-authors. For an overview, see Suzanne Scotchmer, "Standing on the Shoulders of Giants: Cumulative Research and the Patent Law," *Journal of Economic Perspectives*, 5 (1991) 29-41.

[15]For a comprehensive examination of patent litigation trends, see Jean O. Lanjouw and Mark Schankermann, "Enforcing Intellectual Property Rights," STICERD, LSE Economics of Industry Group Discussion Paper: EI/30, 2001.

[16]See Federal Trade Commission, *Report of the U.S. Federal Trade Commission on the Radio Industry in Response to House Resolution 548*, Washington: Government Printing Office, 1924.

The patent litigation explosion and its impact on innovation

Patents have existed for many centuries. It is surprising, then, that one of the actions that triggered the new era of patent policy was an apparently benign change in U.S. judicial procedure. Almost all formal disputes involving patents are tried in the federal judicial system. The initial litigation must be undertaken in a district court. Prior to 1982, appeals of patent cases were heard in the appellate courts of the various circuits. These differed considerably in their interpretation of patent law, with some circuits being more than twice as likely to uphold patent claims as others. These differences persisted because the Supreme Court, which normally steps in to insure national legal uniformity, rarely heard patent-related cases. The justices were reluctant to devote their time to these "banal" commercial disputes.

The result was widespread "forum shopping" in patent cases. Patent applicants would crowd the hallway in the patent office where the list of patent awards was distributed at noon on each Tuesday. Upon discovering that their patent was issued, they would rush to the pay phones to instruct their lawyers to file suit against some alleged infringer of the newly minted patent, filing the lawsuit in a patent-friendly district court, such as Kansas City. Meanwhile, representatives of firms who might be accused of infringing the issued patent would be racing to the phone bank as well, ordering their lawyers to file a lawsuit seeking to have the new patent declared invalid, but filing in a district known to be skeptical of patents—e.g., San Francisco. Such dueling lawsuits would usually be combined into a single action, heard in the district court in which the earliest filing was made. Often the fate of the case—and many millions of dollars in damages—would depend on which lawyer got an earlier date-time stamp on his filing documents.

In 1982, the U.S. Congress decided to address this problem, which was perceived to be undermining the effectiveness of patent protection, and thereby threatening U.S. technological and economic strength. It established a centralized appellate court for patent cases, the Court of Appeals for the Federal Circuit (CAFC). The change was presented in the congressional hearings as a benign one, bringing consistency to the chaotic world of patent litigation, and predictability to the enforcement of valid patent rights. But it was clear from the beginning that advocates of stronger patent protection hoped that the new court would come down squarely on the side of patent holders.

And this is precisely what happened. Over the next decade, in case after case, the court significantly broadened and strengthened the rights of patent holders. One illustration is a comparison of the CAFC's rulings with those of the previous courts. The share of cases where a district court finding of patent infringement was upheld increased, as did the share of cases reversing an earlier finding that a patent was not entitled to damages. Likewise, the CAFC greatly expanded patent-holders' rights along a number of other dimensions, including making it easier to shut down a rival's business even before a patent is proven valid (through a preliminary injunction) and to extract significantly greater damages from infringers.

The consequences of the CAFC's strengthening of the system for enforcing patents have been exacerbated by changes in the behavior of inventors and of the U.S. patent office, which have led to a dramatic increase in the number of patent applications filed, and in the fraction of these applications that are successful in producing granted patents. Decisions of the CAFC encouraged

more patent applications, for three distinct reasons. First, the CAFC made it clear that the realm of patentable subject matter included technologies like software, business methods and certain kinds of biotechnology that hitherto were believed by many to be unpatentable. Second, the new court issued rulings on the standards of "novelty" and "non-obviousness" that made it easier for applicants to qualify for a patent. Finally, the improved enforceability of granted patents encouraged patent applications by making the patent right more economically valuable. As a result, the rate of patent application in the U.S. began to increase shortly after the creation of the CAFC.

The proliferation of patents, many of dubious quality, would sow confusion and legal uncertainty under the best of circumstances, but it has occurred just as the CAFC has been making it easier to *enforce* the rights they convey. The predictable result has been a parallel increase in the number of lawsuits fought over patents. The number of patent lawsuits was roughly constant over the 1960s and 1970s, began to rise with the increase in patent awards in the 1980s, and has ballooned in the past 15 years. Burgeoning patent litigation is increasingly making lawyers rather than entrepreneurs and researchers the key players in competitive struggles. As the patent system becomes a distraction from innovation rather than a source of incentive, the engine of technological progress and economic growth begins to labor.

The pernicious consequences of the evolving patent situation can be seen in two broad kinds of competitive and legal interactions. In one scenario, an established firm, frequently one whose competitive position and innovative activity are declining, realizes it has a valuable stockpile of issued patents. This firm then approaches rivals, demanding that they take out licenses to its patents. In many cases, they will target smaller firms, who do not have extensive financial resources to engage in protracted patent litigation.

Even if the target firm believes that it does not infringe, it may choose to settle rather than fight. The small firm may simply be unable to raise the capital needed to finance a protracted court battle or be unwilling to sacrifice investments in R&D and new facilities to finance the fight. Furthermore, there are substantial indirect costs associated with patent litigation. The pre-trial proceedings and trial are likely to require the alleged infringer to produce extensive documentation and its employees to make time-consuming depositions, and may generate unfavorable publicity. Its officers and directors may also be held individually liable, or be targeted in shareholder lawsuits if the stock price drops.

For numerous large companies—most notoriously, Digital Equipment, IBM, Texas Instruments, and Wang Laboratories—these types of patent enforcement activities have become a line of business in their own right. These firms have established patent licensing units, which have frequently been successful in extracting license agreements and/or past royalties from smaller rivals. For instance, Texas Instruments has netted close to one billion dollars annually from patent licenses and settlements resulting from its general counsel's aggressive enforcement policy. In some years, revenue from these sources has exceeded its net income from actually selling products.

In addition to being forced to pay royalties, small firms may reduce or alter their investment in R&D. Evidence from surveys and practitioner accounts suggest that the time and expense of intellectual property litigation is a major consideration when deciding whether to pursue an

innovation, especially among smaller firms. Smaller firms tend to shy away from pursuing innovations in areas where large firms have established patent portfolios. Thus, these types of enforcement activities by large firms may have the effect of suppressing innovation by younger, more vibrant concerns.

A second worrisome development has been the emergence of individual inventors who seek to "hold up" established firms in their industries. In many cases, these individuals have received a patent of dubious validity, often with overly broad claims. Yet established players have often chosen to settle such disputes, not wishing to risk the uncertainty associated with submitting a complex piece of intellectual property to trial.

Individual inventors will employ various strategies to make the battle more one-sided and drive the large firm to settle the suit. In many cases, the individual inventor will demand a jury trial, and then present himself as engaged in a "David *vs.* Goliath" dispute. He may choose a legal jurisdiction where the residents will be highly unsympathetic to the defendant. For instance, Jerome Lemelson, an individual inventor who claimed to have invented bar-coding technology, filed suits against Japanese and Korean firms in the Southern District of Texas. Similarly, individual inventors frequently threaten corporations with the promise that they will obtain a preliminary injunction, which will stop the defendant from using the patented technology even before the trial begins. While an established business might be reluctant to ask for such a drastic measure, lest the other party seek a similar ban against itself, individual inventors often feel no such compunction. Given the uncertainty of the trial process, the defendant firm frequently decides to settle with an individual inventor rather than fight. In short, the "reforms" of the patent system have created a substantial "innovation tax" that afflicts some of America's most important and creative firms.

So it's hard to get it right

In summary, much is at stake in creating institutions that create incentives for innovation. Because of the inherent riskiness of the innovation process, patents are crucial in many cases to provide enough protection that investors are willing to put up the money to develop new technology. But patents are blunt instruments. Because of the complexity of the evolution of technology, the monopoly that they create will sometimes retard rather than encouraging competition. This means that, in the best of worlds, a patent system is a compromise among competing objectives.

3. The empirical evidence

Given the profound changes which have roiled the global patent system over the past 25 years and the multiplicity of views, it is not surprising that the impact of these changes is attracting increasing attention from the economics profession. A critical question relates to the extent do these changes really affect the pace of innovative discovery and diffusion.

Much of the earlier empirical work has focused on understanding the impacts of a single patent policy reform. Examples include studies of the broadening of Japanese patent scope,[17] the establishment of the Court of Appeals for the Federal Circuit in the United States,[18] and the patenting decision of 19th-century World's Fair exhibitors.[19]. The closest papers to this one are Yi Qian's examination of the changes in pharmaceutical protection world-wide and Branstetter**,** Raymond Fisman**,** and Fritz Foley's examination of the consequence of patent policy changes on foreign direct investment.[20] To highlight the findings of these two papers:

- Qian evaluates the effects of patent protection on pharmaceutical innovations for twenty-six countries that established pharmaceutical patent laws during 1978-2002. Controlling for country characteristics through matched sampling techniques, she finds that national patent protection alone does not stimulate domestic innovation. However, domestic innovation accelerates in the subset of countries with higher levels of economic development, educational attainment, and economic freedom. Additionally, there appears to be an optimal level of intellectual property rights regulation above which further enhancement reduces innovative activities.

- Branstetter and his co-authors examine how technology transfer among U.S. multinational firms changes in response to a series of IPR reforms undertaken by twelve countries over the 1982-99 period. Their analysis of detailed firm-level data reveal that royalty payments for intellectual property and other intangibles transferred to affiliates increase at the time of reforms, as do research and development (R&D) expenditures and patent applications by affiliates. The increases are particularly dramatic for companies that use U.S. patents more extensively prior to reform and therefore are expected to value IPR reform most.

[17]Mariko Sakakibara, and Lee Branstetter. 2001. "Do Stronger Patents Induce More Innovation? Evidence from the 1988 Japanese Patent Law Reforms." *Rand Journal of Economics*, 32(1): 77-100.

[18]Bronwyn H. Hall, and Rosemarie H. Ziedonis. 2001. "The Patent Paradox Revisited: An Empirical Study of Patenting in the U.S. Semiconductor Industry, 1979-1995." *Rand Journal of Economics*, 32(1): 101-128.

[19] Petra Moser, 2005. "How Do Patent Laws Influence Innovation? Evidence from Nineteenth-Century World's Fairs." *American Economic Review*, 95(4): 1214–36.

[20] Lee Branstetter, Raymond Fisman, and Fritz Foley. 2006. "Do Stronger Intellectual Property Rights Increase International Technology Transfer? Empirical Evidence from U.S. Firm-Level Data." *Quarterly Journal of Economics*, 121(1): 321-349; and Qian, Yi. 2007. "Do National Patent Laws Stimulate Domestic Innovation in a Global Patenting Environment?" *Review of Economics and Statistics*, 89(3): 436-453.

I will discuss at more length my work examining the impact of major patent policy shifts in sixty nations over the past 150 years.[21] I examine the changes in patent applications by residents of the nation undertaking the policy change. While I tabulate domestic filings by residents and non-residents alike, confounding factors may influence this measure. Thus, I also examine filings made by residents of the nation undertaking the policy change *in a nation with a relatively constant patent policy*, Great Britain.

I employed as my sample the sixty countries listed in the International Monetary Fund's *International Financial Statistics* with the highest total gross domestic product (GDP) in 1997. I then identified significant changes to the amount of patent protection offered. I determined this information using guidebooks to the world patent systems, publications of the world's patent offices, and legal monographs. I focus on shifts in the most visible and controversial areas of patent policy: whether the country offered comprehensive patent protection, the length of patents, the cost of awards, and provisions for patent revocation. I did not consider changes to the breadth of patent protection: in these cases, the interpretation of changes in the volume of domestic patenting would be problematic.

I identified 177 events in 51 out of the 60 nations in the sample. The number of events and distinct policy changes occurring in each decade are depicted in Figure I present the number of changes, divided by the number of nations that were active at the beginning of the decade.

The next phase was to determine the patent applications filed around the time of the policy changes. Using patent office publications, I identified three distinct measures of activity: patent filings in Great Britain by residents of the country undertaking the policy change, patent applications by domestic entities in the country undertaking the policy change, and applications by foreign entities in that country. I chose Great Britain because its patent office has consistently tabulated the national identity of the patent applicants since 1884 (except during World War I) and the relative constancy of its patent policy. In these tabulations, I sought to only include traditional patent awards, eliminating various weaker variants that nations have sometimes also offered.

Panel A of Table 1 reports the changes in patent applications filed from two years before to two years after the policy shift. I divided the observations by the type of policy change. Most shifts (64%) unambiguously increased patent protection. The remainder either unambiguously reduced patent protection (24%) or else contained both protection-enhancing and detracting elements (12%). In view of the small sample sizes, I treated the ambiguous and negative changes together in the reported analyses.

Domestic and foreign patent applications both increased in countries undertaking patent protection-enhancing shifts. The increase was larger, on both an absolute and percentage basis, among the foreign applicants. (In the sample as a whole, the mean number of British, domestic, and foreign patent applications during the year of the policy change were 739, 13,296, and

[21] Josh Lerner, 2009, "The Empirical Impact of Intellectual Property Rights on Innovation: Puzzles and Clues," *American Economic Review Papers and Proceedings*, ____.

14,118 respectively.) No evidence appeared of a rise in British patent applications by residents of the nation where the policy change occurred.

Panel A does not, however, control for changes in the overall propensity to seek patent protection over the period. Some periods, such as the depression years of the 1930s and the two world wars, saw a dramatic decline in patent applications across all nations, while others saw a substantial increase. I thus computed the "adjusted" difference: the difference in the number of patent applications filed in the [-2, +2] interval, less the difference that would have been expected, had the applications grown at the same rate as in other countries. To determine the growth rate elsewhere, I constructed an index using the ten nations with the longest time series of patent application data. These nations included some where patenting has grown dramatically (e.g., the U.S.) and others where it has not (for instance, Argentina). In Panels B and C, I report the analysis using two indexes, one assigning an equal weight to each of the ten nations, and one weighting each observation by the total patent applications filed. In each case, I compute the difference in the number of applications filed two years after the policy shift and two years before the shift, less the predicted change has the number of applications followed the trend of the index.

Once the adjustment for overall patent application growth was made, a stark difference appeared in the case of patent protection-enhancing changes. While the change in foreign patenting was positive, adjusted patent applications by residents of the country undergoing the policy change declined, whether British or domestic filings were considered. The response of foreign patenting was much more modest in magnitude in the case of protection-reducing and ambiguous changes. I also report the statistical significance of these changes. In the financial event study literature, a standard procedure for computing test statistics for event studies has emerged. First, the standard deviation of returns during an estimation period, which does not overlap with the event window, is computed. Each observation is then weighted by the inverse of the standard deviation when undertaking univariate or regression analyses.[22] In this way, observations where the stock price is very volatile are assigned less weight. In the same spirit, I computed the standard deviation of the change in patent applications filed in the period from twenty years to five years prior to the policy shift. I weighted both the t-tests and the regression analyses by the inverse of the standard deviation. Not only did the adjusted patenting by residents of the country undertaking the policy change not increase after patent protection-enhancing policy shifts, it actually fell by a significant amount. Foreign applications, however, reacted positively to protection-enhancing changes, suggesting that I had identified a set of significant policy shifts.

Figure 2 depicts graphically the average changes in patent applications around protection-enhancing changes, net of the value-weighted index. Around protection-enhancing changes, the same striking pattern appeared: patent applications by foreign entities increased dramatically, while filings by domestic entities (whether in Great Britain or in the country undergoing the policy change) fell on an adjusted basis. (The fact that these changes began in the years before

[22] See Stephen J. Brown, and Jerold B. Warner. 1980. "Measuring Security Price Performance." *Journal of Financial Economics*, 8(3): 205-258.

the policy change may reflect lags in the policy process. In many instances, changes were discussed for years before being implemented, and hence partially anticipated.) Around ambiguous or protection-reducing changes, the changes in filings were much more modest.

One concern with the above analysis was that it might be inappropriate to use the same index for each class of patent applications. For instance, the propensity of applicants to file foreign patents may have grown much more quickly than the tendency to file domestically. In this case, the adjustment process may lead to the growth of domestic patenting being understated, and that of foreign patenting overstated. To address this concern, in an unreported analysis I explored the robustness of these patterns to the use of alternative indexes based on just the same type of patenting. In other unreported analyses, I adjusted the composition of the countries in the indexes. The changes had a very modest impact on the analysis.

I analyze econometrically in Table 2 the adjusted growth in patenting in Great Britain by residents of the country undertaking the policy change. As independent variables, I employed dummy variables denoting whether the policy represented a patent protection-enhancing change and whether protection prior to the policy change was particularly strong, and their interaction. I used the length of patent protection to designate countries with particularly strong protection (those where patents extended eighteen or more years from the application date). As controls, I used the type of policy change, the inception of a conflict on the territory of or a change in the boundaries of the nation during the event window, the number of patent applications filed two years before the policy change, and the population of the nation (in millions). I again weighted each observation by the inverse of the standard deviation of changes in patent applications during the estimation period. The dummy variable indicating a patent protection-enhancing policy shift was significantly positive, while the interaction was significantly negative. This suggests that enhancing patent protection was less effective when patent protection was already strong, consistent with Gallini (1992).

The lack of a positive impact of strengthening of patent protection on innovation is a puzzling result. Not only does it run against our intuition as economists that incentives affect behavior, but also runs counter to the findings in the "law and finance" literature that stronger property rights (e.g., those giving equity-holders more prerogatives) encourage economic growth.

Three explanations can address this seeming paradox:

- The measures of innovative output are crude ones. Due to the broad scope and long time frame of this analysis, I was required to use patent-based measures of innovation. The mapping between what I seek to measure (innovative activity) and the dependent variable in this analysis (patent applications) is not exact, though only examining the changes in patenting levels should limit this problem.

- The time frames may be too short. Other effects might have also been identified had I examined changes over longer event windows, since some of the policy changes could have taken more than five years to impact domestic innovation. In the short run, for

instance, increased foreign investment may "crowd out" innovation by domestic entities. In the longer run, as the experiences of the Indian and Israeli information technology industries suggest, increases in foreign patenting and investment (Branstetter, et al. [2006]) may be an important channel through which domestic innovation is spurred.

- Despite these caveats, the failure of domestic patenting to respond to enhancements of patent protection, and the particularly weak effects seen in developing nations (in the unreported regressions), were quite striking. The impact of strengthened patent protection may simply be far less on innovative activities than much of economics and policy literature assumes.

Final thoughts

Governments today are facing the challenge of finding the appropriate degree of intellectual property protection. Despite the intense public interest, there are no easy answers here. On the one hand, patent protection can serve as a necessary spur to innovation; on the other, too strong or wrongly applied property rights can introduce problematic distortions. The evidence regarding the impacts of these rights on innovation is mixed, suggesting that there can be both too much as well as too little protection.

Among the crucial questions for future research are as follows:

- Better understanding the weak relationship between strengthened intellectual property rights and innovation. Both the work of Branstetter and co-authors and Lerner do not suggest a strong positive association between domestic patenting and protection. This poses a substantial puzzle, as discussed above. Better understanding the consequences of strengthened protection —whether through case studies of particular countries or new, more refined data-sets—is a major need.

- Exploring the ability of firms to "work around" intellectual property protection through knowledge-sharing-organizations. Recent years have seen an explosion in the number and activities of patent pools, standard-setting bodies, and open source collectives. We still do not know, however, much about how effective these organizations are in overcoming "patent thicket" problems and promoting innovation.

- Moving beyond studying patents to scrutinizing other forms of intellectual property protections. As noted in the introduction, patents have attracted the lion's share of attention in economic researchers on the consequences of intellectual property and innovation. But copyright and especially trade secrets can play a critical role here. While data issues are more daunting in other realms, these issues are important and worthy of the effort that will be required to explore them.

Figure 1. Number of changes in patent policy over time. The sample consists of the sixty largest countries (by GDP) at the end of 1997, observed from 1850 (or the date of inception as an independent entity) to 1999. The chart presents the number of policy reforms, as well as that of distinct policy shifts, in each decade, normalized by the number of active countries in the sample at the beginning of the decade.

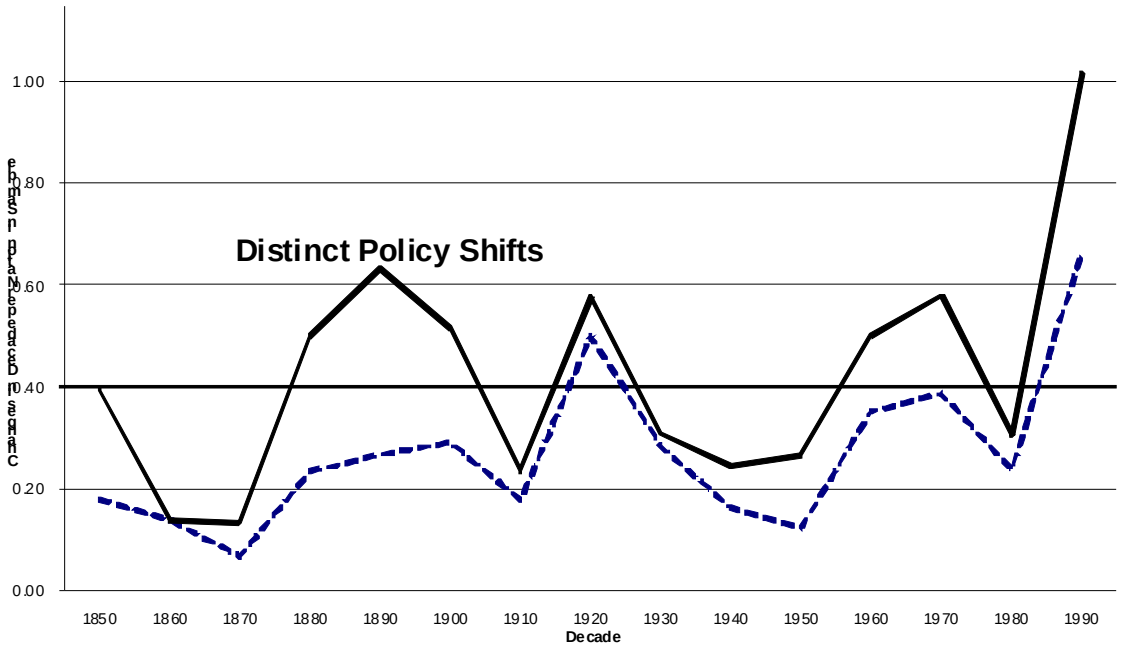

Table 1: Change in on patenting activity around policy shifts (year -2 to +2).

Panel A: Unadjusted Changes in Patenting Around Policy Changes			
	Residents' Patenting in Great Britain	*Residents' Patenting in Country*	*Foreign Patenting in Country*
Positive Patent Policy Changes	-27	+2424	+8662
Ambiguous/Negative Changes	+210	+529	+1401
Panel B: Changes in Patenting, Adjusted by Equal-Weighted Index			
	Residents' Patenting in Great Britain	*Residents' Patenting in Country*	*Foreign Patenting in Country*
Positive Patent Policy Changes	-101	-1617	+4979
	***[4.61]	*[1.86]	**[2.41]
Ambiguous/Negative Changes	-217	-525	+390
	***[3.19]	[0.34]	[1.28]
Panel C: Changes in Patenting, Adjusted by Value-Weighted Index			
	Residents' Patenting in Great Britain	*Residents' Patenting in Country*	*Foreign Patenting in Country*
Positive Patent Policy Changes	-100	-932	+5617
	***[4.52]	*[1.69]	***[2.85]
Ambiguous/Negative Changes	-137	-408	+501
	**[2.40]	[0.07]	[1.65]

**** = Significant at the 10% confidence level; ** = 5% level; *** = 1% level.***

Figure 2. Impact of patent protection-enhancing policy changes. The figure displays the change in the number of patent applications filed between five years before the event and five years after the event by domestic entities filing in the country undertaking the change, foreign entities filing in the country undertaking the change, and residents of the country undertaking the policy change in Great Britain. These changes are shown net of a value-weighted index of patenting in the ten nations with the longest time series of application data.

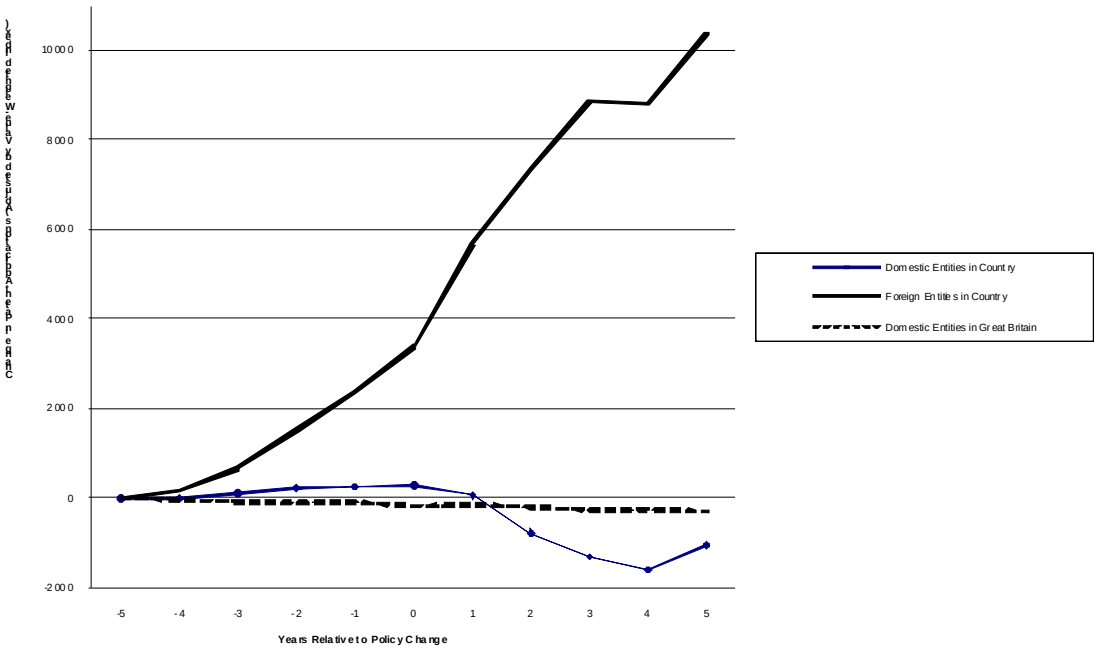

Table 2. Weighted least squares regression analyses. The dependent variable is the change in the number of patent applications filed by residents of the country undertaking the policy change in Great Britain from two years prior to the policy change to two years afterwards, net of an equal-weighted (EW) index of patenting in the ten nations with the longest time series of application data. Each observation is weighted by the inverse of the standard deviation of the annual change in patent applications in Great Britain from twenty to five years before the policy change. Absolute t-statistics in parentheses.

Dependent Variable:	*Change in U.K. Applications, Net of EW Index*
Positive Patent Policy Change?	***598.53 [3.24]
Strong Protection Prior to Change?	86.93 [0.35]
Strong Protection * Positive Change	***-980.07 [3.34]
Inception of Conflict?	-332.82 [1.09]
Change in Territory?	130.20 [0.43]
Applications Two Years before Event	***-0.13 [13.14]
Population of Nation	0.27 [0.29]
Dummies for Policy Change Type	Included
Number of Observations	159
F-Statistic	23.14
p-Value	0.000
Adjusted R^2	0.61

*** = Significant at the 10% confidence level; ** = 5% level; *** = 1% level.**

Concept House
Cardiff Road
Newport
NP10 8QQ

Tel: 08459 500 505
Minicom: 08459 222 250
Fax: 01633 817 777

www.ipo.gov.uk

When you no longer need this booklet, please recycle it.

Revised: June 09

DPS/c550-06-09