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Abstract: Do patents provide critical incentives to encourage investment in innovation? Or, instead, do patents impose legal risks and burdens on innovators that discourage innovation, as some critics now claim? This paper reviews empirical economic evidence on how well patents perform as a property system.

1 Introduction

Perhaps one of the clearest lessons of the Cold War is that private property and market economies can be powerful engines of economic growth and innovation. Although centralized economies mustered impressive economic effort, especially in wartime, they failed to provide a high and rapidly growing standard of living. Moreover, what they did achieve sometimes came at a horrible human cost.

The experience of the Cold War seems to lend force to arguments that intellectual property also promotes economic growth and innovation. Indeed, it is now often argued that the institutions responsible for the success of Western economies are "the rule of law and private property rights, including intellectual property."[1] These arguments are important today because patent reform is on the legislative agenda once again, the result of growing discontent with the patent system in some industries.

These are seductive arguments. There is solid empirical evidence that secure property rights are conducive to economic growth. So it might seem to follow that "strong" patent rights should also promote innovation and economic growth. But what is the actual empirical evidence that patents and other forms of intellectual property are responsible for the technological leadership of the U.S. and the West?

Casual observation suggests that the U.S. and other Western nations share both technologically advanced economies and well-developed patent systems. But this is a correlation, not evidence of causation. That is, well-developed patent systems might cause economic growth in these nations. Or it might be, instead, that successful technology companies or other groups, such as the patent bar, have lobbied for patent protection. In this latter case,

1 Mark Schultz, "The Ideological War over Intellectual Property," Tech Central Station, 2005, http://www.techcentralstation.com/050205A.html.

economic success promotes the expansion of the patent system, not the other way around. Indeed, the patent systems in advanced nations today consist of highly sophisticated institutions supported with substantial funds. These institutions were not simply legislated, but they developed, along with a wide variety of other legal and social institutions. Their evolution required both extensive experience and a large allocation of resources and they would seem as out of place in 19th century America as they would in many of today's less developed nations. Thus the correlation between the sophistication of a nation's technology and the sophistication of its patent system does not provide evidence of a causal link by itself. A more advanced analysis is required.

This paper surveys empirical research on the economic performance of patents, comparing this research to similar research on property rights. Our objective is not to obtain a conclusive finding on whether patents are good policy instruments or not, whether, for instance, they increase "net social welfare." Instead, we simply aim to compare the evidence of economic payoff from general property rights to the evidence on the economic payoff from patents. If the analogy to property is close, then we should see similar evidence of economic payoff.

As we shall see, the evidence paints a rather mixed picture. In some industries, such as pharmaceuticals, patents provide strong positive incentives to invest in innovation. But in many other industries, perhaps most, patents fail to perform like property and they may actually discourage innovation.

2 Comparing the evidence on property rights and patents

In what ways might we expect patent rights to perform similarly to rights in tangible property? Property rights provide incentives to invest, to trade and to finance. Similar economic benefits are ascribed to patents. Patents provide incentives to invest in R&D and other innovative

effort. Patents also provide incentives to invest in the commercialization and further development of an invention and for investors to invest in companies holding patents. In addition, patents provide security to license and sell technology. These incentives are held to promote innovation and economic growth.

We look at five sorts of evidence about the links between property, patents, innovation and economic growth: evidence from economic history, especially from the Industrial Revolution; cross-country econometric studies; evidence from "natural economic experiments," observing the impact of discrete changes in patent law; evidence about the effect of imitation; and direct evidence about the benefits and costs of patents to their owners.

2.1 Historical Evidence

Economic historian and Nobel-laureate Douglass C. North has argued persuasively that the British Industrial Revolution was facilitated by secure property rights (1981). Many European nations were hobbled with feudal customary rights that were often disputed, undocumented and hard to establish. In contrast, by the time of the Industrial Revolution, Joel Mokyr writes, Britain's government was "one of, by, and for private property" (1999, p.45). Britain had well-defined private property rights, less arbitrary courts and police, and institutions that limited confiscatory taxation (North and Weingast 1989). This reduced transaction costs and encouraged the growth of markets, allowing for greater specialization, economies of scale, and more secure returns on investment. These benefits are seen as important preconditions for the innovations and, ultimately, the economic growth that arose from the Industrial Revolution.

North includes patents among Britain's advantageous property rights during the Industrial Revolution. Britain's patent law dates from 1624, while most other European countries did not have patent laws until the end of the eighteenth century. But more than a few economic

historians are skeptical about the significance of patents for the British Industrial Revolution, as Joel Mokyr (1999) notes.[2]

One reason for Mokyr's skepticism is that relatively few inventors of key technologies prior to the mid-nineteenth century seemed to benefit from patents. James Hargreaves and Samuel Crompton, inventors of cotton spinning machines, did not obtain patents (Crompton was later compensated by Parliament). Crompton did not obtain a patent because Richard Arkwright held a broad patent on spinning technology. Arkwright had patents, but his key patent was challenged and invalidated; he nevertheless made a fortune. Edmund Cartwright, inventor of the power loom (an automatic loom), and Richard Roberts, inventor of a successful automatic spinning machine, both obtained patents on these inventions, but were unable to earn profits from them, despite the ultimately wide adoption of their machines. John Kay, inventor of an improved weaving shuttle, and the Fourdrinier brothers, inventors of a paper-making machine, were both nearly ruined by the costs of patent litigation.

James Watt is a happy and prominent exception: Watt obtained a patent on his improved steam engine design and, thanks in part to Parliament's extension of their patent term, the firm of Boulton and Watt made a substantial return on the investment needed to commercialize the invention. But we should not overestimate the significance of Watt's example. His reputation appears to have outpaced the merit of his inventions (MacLeod 1998), which made only a limited contribution to economic growth (von Tunzelman 1978).[3] Most of the impact of the steam engine on economic growth appears to have come much later, after many additional improvements had been made in steam engine efficiency (Crafts 2004). This is significant because Nuvolari (2004) shows that most of this later increase in efficiency can be attributed to

2 Mokyr reviews the literature, concluding "The exact role of the patent system in Britain's Industrial Revolution is hard to determine."

"collective invention," where engineers actively shared inventions rather than patented them.

Economic historians have suggested several reasons why patents may not have played a role more similar to other property rights in Britain. A major problem was that patent litigation was costly and risky.[4] Courts were not always sympathetic to patent holders, patent law was complex and patents could be invalidated (Mokyr 1999, p. 43). Litigation may have been more common than necessary because Britain had a registration system instead of patent examination. British patents were not examined for novelty or inventive step prior to the twentieth century. One study found that 42% of patents were either partly or wholly anticipated by earlier patents and many inventions were patented multiple times (MacLeod et al. 2003, p. 541). Also, prior to 1883, the British patent system was very costly, both in fees and in the indirect costs of bureaucratic red tape.

Dutton (1984) is perhaps the economic historian with the most optimistic interpretation of the British experience. He cites evidence that hundreds of inventors did patent, many obtained multiple patents, and that there was some trade in patents. This suggests that some inventors obtained *some* benefit from patents. But, this does not mean that they received a *net* benefit from patents—the costs of litigation and disputes can easily offset the gains. Dutton and others recognize that these latter costs were substantial. He floats the idea that despite these major problems, patents may have encouraged innovation because perhaps inventors accepted the "socially wholesome illusion" that the patent system was more perfect than it really was. But Christine MacLeod (1988, p. 145) finds that about nine out of ten patents arose in industries that

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3 Boldrin and Levine (2005) question whether Watt's patent may have even held up further improvements.

4 The percentage of patents contested grew from 1.5% during the late 18th century to 2.8% during the 1840s (Dutton 1984). The majority of court decisions went against patentees during the early 19th century but this reversed mid-century (Dutton 1984, Ch. 9). Dutton quotes, among others, Charles Babbage who wrote that patent law creates "factitious privilages of little value," where "the most exalted officers of the State in the position of a legalised banditto...stab the inventor through the folds of an Act of Parliament and rifle him in the presence of the Lord Chief Justice of England." (Quarterly Review XLIII, 1830, p. 333)

saw little innovation, and that patenting was at best loosely related to technological innovation. And although there were some inventors who obtained ten or more patents and although there was some trade in patents, the numbers were small especially in comparison to those in the United States, even though the U.S. lagged in economic development.[5] Moser (2006), using information on inventions exhibited at the 1851 Crystal Palace Worlds Fair, finds that only 11% of British inventions were patented. So it seems particularly hard to argue that British patents played a very *significant* role during the Industrial Revolution, even if some inventors had irrational expectations of the patent system.

Indeed, the experience in the United States was quite different from that in Britain.[6] The US initiated patent examination in 1836 and patent fees were quite low. When examination standards were relaxed during the 1850s, patent applications soared (Post 1976), leading to what Zorina Khan calls "The Democratization of Invention" (2005). Individual mechanics and farmers could and did obtain patents in large numbers and an active market for patents developed that lasted until the end of the century. And although there were some well-known cases where patents were "invented around," such as Eli Whitney's cotton gin and Francis Cabot Lowell's power loom (which he himself copied from British models), many of the famous inventors in the US did make profits from patented inventions (Khan and Sokoloff 1993).

So patents may have played a more positive role in the economic growth of the US, although research has not yet established the extent of this contribution. On the other hand, the ready availability of patents also had a possible dark side: it permitted small groups or individual

5 Dutton reports 69 inventors with 10 or more patents during the century from 1751 through 1852, but there were 192 US inventors with 10 or more patents during the shorter interval from 1790-1846 (Khan and Sokoloff 1990). Dutton reports about 19% of British patents were re-assigned; Khan reports that the rate of re-assignment for U.S. patents was about 80% during the 1870s (Khan 2005).

6 Nard and Morriss argue that in 1790, the Americans fashioned a patent system superior to the British system because there were no forces organized to extract rents from the legislation – there was no independent inventors lobby, or industry lobby like today's pharmaceutical industry. Britain had to contend with royal prerogative and

firms to accumulate patent "thickets" or to set up patent pools, which may have substantially extended their market power and posed entry barriers or disincentives to other innovators. The first patent pool was formed for sewing machines in 1856 after extensive litigation. Also in the 1850s, the Draper Co. perfected the technique of amassing a large number of patents to extend their monopoly, first with patents on loom temples, then with spinning spindles beginning in the 1870s and later with the Northrup automatic loom in the 1890s (Mass 1989). They controlled over 400 patents on spindles and over 2,000 patents on the automatic loom. This arsenal and their aggressive litigation posture allowed them to monopolize key textile equipment for many decades.

Despite its faults, the US patent system possibly had a much more positive effect on innovation and economic growth than the British system. But the differences only underline the contingent nature of the benefits of a patent system. They depend very much on the details of the system and the nature of the institutions that support it.

There were also important differences across industries and technologies. This is evident in Petra Moser's research on the effect of patents on innovation in different countries during the nineteenth century (2004). Moser looks at differences in innovation across countries during the mid-nineteenth century. She measures national innovation by looking at the number of important innovations (selected by panels of experts at the time) each nation displayed at world's fairs in 1851 and 1876. She finds that nations with patent systems were no more innovative than nations without patent systems. Similarly, nations with longer patent terms were no more innovative than nations with shorter patent terms. However, patents did seem to make a difference in national patterns of specialization. In countries without patents, innovation was centered in industries that appeared to have strong trade secrecy protection; in countries with patents, this was not the case.

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favored manufacturers at the start of its patent system.

So, in contrast to general property rights, patents had a much more uneven and limited effect on economic development during the nineteenth century. The role of patents seems to have varied depending on the specific features of patent institutions, the technologies and industries involved.

2.2 Cross-country studies

In recent years, economists have developed a large literature comparing the economic performance of different countries as a means of identifying factors that influence economic growth. These studies use panels of data that typically consist of dozens of countries observed over several decades. They conduct multiple regression analyses to control for a wide variety of factors that are thought to influence growth. Property rights institutions have featured prominently in this literature. Patent and other intellectual property rights also appear in several studies — the results for these measures have been quite different from the results for more general measures of property rights.

Early studies used measures of political instability and measures of civil rights as proxies for the quality of property rights institutions. Keefer and Knack (1995, 1997) developed indices that capture contract enforceability, risk of government expropriation, rule of law, constraints on the executive branch of government and bureaucratic quality. They incorporated these in a regression of each country's per capita economic growth rate, including additional controls for education, labor force growth and other factors. Across a variety of specifications, they found that the quality of property rights institutions is strongly and positively correlated with a nation's economic growth rate.

Keefer and Knack did not control for "reverse causality," that is, for the possibility that economic growth may have caused improvements in property rights institutions instead of the

other way around. As above, this might be the case if, say, wealthier nations tended to allocate more resources to improving property institutions because wealthier nations have more property potentially at risk from bad institutions. Hall and Jones (1999) build a similar model that does control for reverse causality.[7] Again, the property variables show a strong relationship with economic growth.

The same cannot be said for patents or intellectual property rights. Gould and Gruben (1996) use a measure of a country's strength of patent protection in a regression similar to that of Keefer and Knack. In their base model the patent index has a positive coefficient, but it is not statistically significant. They try a wide variety of other specifications and interactions and in a few cases they obtain coefficients that are statistically significant, but most results are only weakly significant. Moreover, this study has some important limitations that make any results difficult to interpret. In particular, these regressions do not include measures of other property rights—one might expect patent rights to be correlated with other property rights, which, as above, are known to have a positive effect on economic growth—nor do they control for reverse causality.

Park and Ginarte (1997) conducted a more elaborate study that included measures of general property rights, specifically an index of "market freedom." They also used a more sophisticated measure of a country's patent rights[8] and a more sophisticated estimation technique. In their base regression, they find that the market freedom variable has a positive and statistically significant effect on economic growth but the intellectual property rights index has a

7 They perform instrumental variable regressions, using instruments such as distance from the equator and the primary language of the country.

8 The index is based on five characteristics of the country's patent law: 1) the extent of patent coverage, including pharmaceuticals and chemicals, 2) whether the country participates in international patent treaties, 3) whether patent law includes compulsory licensing or working requirements that might result in a loss of patent rights, 4) whether patent law has features such as preliminary injunctions that make it easier for patent holders to enforce patents, and 4) patent term. Note that these measures reflect the law on the books, not the actual working of

negative coefficient that is not statistically different from zero. However, although intellectual property rights do not appear to have a direct positive effect on economic growth, they find some limited evidence that intellectual property rights are correlated with a country's R&D spending (see also Kanwar and Evenson 2003). It might be the case that intellectual property rights encourage R&D spending, but that this effect is too small to show up as a major direct influence on economic growth. But even this result is limited for two reasons. First, Ginarte and Park find that it only holds among the wealthier countries in their sample.[9] Second, they do not control for reverse causality—that is, firms that spend a lot of R&D might, after they become established, lobby for stronger patent laws.

In a separate paper Ginarte and Park (1997) look at the factors that determine a country's intellectual property rights (the same index). They find, in fact, that lagged R&D (R&D from five years earlier) is positively correlated with subsequent intellectual property rights strength. This suggests that there is, indeed, a significant reverse causality.

In summary, the qualitative difference between regression results for general property rights and those for intellectual property rights is striking. General property rights have a strong and direct influence on economic growth that is robust to a wide variety of specifications and to controls for reverse causality. In contrast, intellectual property rights appear to have at best only a weak and indirect relationship to economic growth, this relationship appears to apply only to certain groups of countries or certain specifications, and the direction of causality is unclear.

Intellectual property rights are *not* just like other property rights and simple casual observations about the correlation between US or Western technology and patent systems can be misleading. On the other hand, this does not mean that patents have no measurable effects, just

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patent institutions.

[9] Falvey et al. (2006) find a positive relationship between the strength of intellectual property rights and economic

that it appears that their effects may be more tentative, contingent upon the details of the patent system or dependent on the particular technology, industry or state of economic development.

2.3 Natural Economic Experiments

One way that researchers have sought to untangle the direction of causality is to look at "natural economic experiments:" they compare economic activity before and after a discrete change in the law. Even though economic policy may have changed in response to "endogenous" factors, such as successful firms lobbying for stronger property rights, when the change occurs as a sharp break, the effect of that change should be observable immediately after it goes into effect. There are studies of natural economic experiments both for changes in property rights generally and for patent rights specifically.

Perhaps the biggest economic experiment in recent years is the transition of Eastern European economies from centralized planning to market-based economies beginning with the collapse of the Soviet system in the late 1980s. Svejnar (2002) studies the economic performance of the countries making this transition twelve years hence. Per capita GNP growth had fallen steadily in Soviet Bloc countries for decades to a level of 0.8 percent growth per annum during the 1980s. Economists had high expectations that moving to a market system would generate a rapid increase in economic growth.

This did not happen. Per capita GNP fell rapidly in all the countries, but some eventually recovered and entered a period of positive and, in some cases, rapid economic growth. The outcome apparently depended on the particular set of reforms each country put into place. Svejnar distinguishes two levels of reforms. Almost all of the countries initiated "Type I" reforms involving macro-economic stabilization policies, removal of price controls and subsidies

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growth for wealthy countries and the poorest countries, but not middle income countries.

and dismantling of the institutions of the communist system. Some countries—notably Poland, Hungary, Slovakia and Slovenia—also pursued "Type II" reforms that permitted the development of government policies and institutions to support a robust market economy. These included privatization of large enterprises and establishment of effective market-oriented legal systems, commercial banking, regulatory infrastructure and labor market regulation. These latter reforms were critical in providing a reliable tax base for government agencies and for limiting corruption and rent-seeking behavior. And they appear to have made the crucial difference in economic performance—the countries that initiated Type II reforms now have strong economic growth in contrast to those countries that put into place more limited institutional change.

This analysis suggests that when it comes to the economic effects of property, the devil is in the details. It is not enough to eliminate centralized control and to provide legal rights to property. Effective economic performance depends on well-developed public and private institutions to support the property system and these are often more difficult to develop.

The evidence from changes in patent law suggests that the devil may be even more deeply hidden in the details of patent institutions. Sakakibara and Branstetter (2001) look at the effect of a 1988 law that increased patent scope in Japan. They found no evidence of an increase in either R&D spending or innovative output which could be plausibly attributed to the patent reform. Bessen and Hunt (2004) look at the effect of changes in the US treatment of inventions that involve software. They found that the number of software patents grew dramatically. However, firms in the software industry acquired relatively few patents; instead, most were obtained by firms in electronics and computer industries known for stockpiling large arsenals of patents to use as bargaining chips. Moreover, the firms that acquired relatively more software patents tended to actually *reduce* their level of R&D spending relative to sales.

Several studies have looked at the effect of extending patent protection to pharmaceutical

products and processes. Many countries historically have limited patent coverage of pharmaceuticals, but they extended coverage in recent decades under pressure from trade negotiators. Scherer and Weisburst (1995, see also Challu 1995) studied the effect of strengthened drug patents introduced in Italy in 1978. They found no evidence that drug R&D accelerated within the well-established Italian drug manufacturing industry after the law change.[10] Lanjouw and Cockburn (2001) study the effect of the TRIPS treaty, which went into effect in 1995 and which required about 40 less developed signatory countries to implement pharmaceutical patent protection by 2005. Among other things, they look at the R&D allocated to products specifically directed to less developed country markets. They find some increase in spending during the mid- and late-1980s, perhaps in anticipation of the changes. However, these trends actually appear to have leveled off or reversed during the 1990s when the TRIPS changes went into effect.

{Figure 1 about here}

All of these studies are subject to the caveat that other, simultaneous changes might possibly cause a reduction in innovation or in R&D, potentially confounding the results. The similarity of results across these various studies suggests that confounding factors are not responsible for most of what has been observed. One study uses the power of numbers to limit the explanatory role of possible confounding effects. Josh Lerner (2000, 2002) looks at 177 changes in patent law that "strengthened" patents in a panel of 60 countries over 150 years. In such a large sample the role of confounding factors should be limited—positive confounding events will tend to be offset by other negative confounding events in estimates of the average response. In his accounting of events that strengthened patents, Lerner includes changes in

10 Italian firms did obtain more patents in the US after the change, but the authors attribute this to a change in the propensity to obtain a patent, not to a greater rate of invention.

substantive law that improved the scope or extent of patent rights and he also includes reductions in patent fees.[11] Although the latter does not strictly imply an increase in patent rights, inventors have been found to increase their rates of patenting in response to cheaper patents (Macleod et al. 2003). Lerner is not able to directly measure the effect of these changes on innovation. Instead, he measures their effect on patenting within the country making the change and also the effect on patenting by domestic inventors at Great Britain's Patent Office. He finds that overall foreign inventors increased their patenting in countries that strengthened their patent laws (see Figure 1). However, *domestic* inventors actually patented *at a lower rate* after the change, both within their country and at the British Patent Office. Exploring alternative specifications, Lerner finds that this decline applies more to poor nations and nations with initially lower levels of patent protection. Nevertheless, the overall results seem consistent with the studies of changes in pharmaceutical patent coverage: it may benefit foreign inventors who trade in patented goods, but it is not clear from these studies that stronger patent laws improve domestic innovation.

Qian (2006) conducts a detailed cross-country study of changes in pharmaceutical patent coverage from 1978 to 2002, controlling for general property rights and other variables that might affect pharmaceutical innovation. Like Lerner, she finds that, in general, changes strengthening patent coverage for pharmaceuticals do not increase domestic innovation. She also finds some evidence of a positive effect on innovation among more developed countries with greater educational attainment and more market freedom. However, even this effect is limited: at high levels of patent "strength," additional strengthening measures actually decrease innovation.

11 Lerner classifies changes in patent policy as "strengthening" if they included: 1) increases in the subject matter covered by patents, including the initiation of patent coverage of any sort; 2) extensions in the length of the patent term; 3) reductions in patent fees; and 4) elimination of limitations on patent grants, including elimination of requirements that patents must be "worked" (put to commercial use) to avoid revocation or compulsory licensing.

2.4 Empirical Evidence on Free-Riding

It is helpful to ask whether patents do, in fact, play the role prescribed for them in economic theory. The standard argument is that without patents, inventions will be quickly copied by imitators. Competition from these "free-riders" will drive down prices, making it impossible for the inventor to earn sufficient profits to recoup his investment in developing the invention. Without the promise of secure profits, inventors will not invest in the first place, so the argument goes.[12]

This is a plausible and oft-told tale, but what is the actual evidence to support it? Do patents prevent the market entry of free-riders who would otherwise destroy or reduce incentives to innovate? Empirical research suggests that the answer is "sometimes" and "to some extent." This may help explain the nature of the findings described above.

The canonical example of the free-riding problem is traditional drug development (biotech is different in some important respects). Dimasi et al. (2003) estimate that the average out-of-pocket cost for a drug company to develop a new drug, including the costs of research projects that were abandoned, is $402 million (2000 dollars undiscounted). About 70% of this cost is incurred during the clinical trials necessary to obtain government approval. Generic drug manufacturers are not required to repeat these same clinical trials, so their R&D costs are far less than those of the original manufacturer. This means that when patents expire, generic manufacturers can enter the market and compete at lower prices. Grabowski and Vernon (2000) find that prices drop to 37% of their original level two years after the entry of generic manufacturers. The higher prices that pharmaceutical firms charge while they are still on patent allow them to earn above-normal profits, "rents," that more than recoup their development investments (Dimasi et al. 2003).

But the pharmaceutical industry may be atypical. Certainly, few other industries have such a high regulatory burden on initial innovation. Typically, imitators are not at such a large cost advantage relative to initial innovators. Mansfield et al. (1981), using survey data, find that imitation cost and imitation time are about two-thirds of the original development cost and time on average. This is still an advantage for imitators, but not such a large advantage. It means that imitators have significant entry costs.

Also, perhaps the nature of pharmaceutical patents—patents on small, well-defined molecules—may enhance the effectiveness of patenting in this industry. These patents have clear boundaries which promote efficient enforcement of the patent rights. Survey respondents told Mansfield et al. that patents increased imitation costs only 7% for electronics and machinery inventions at the median; the figure was 30% for pharmaceutical inventions.

More generally, imitation costs are high aside from patents because firms have means other than patents for protecting their innovations. Innovators may earn above-normal profits because they have lead time advantages, or because they come down a learning curve first; they may earn profits from complementary products and services, or they may rely on trade secrecy. Surveys find that in most industries (pharmaceuticals are the exception!) R&D managers report that these other means of appropriation are more effective than patents in obtaining returns on their R&D investments (Levin et al. 1987, Cohen et al. 2000). For this reason, it is not surprising that survey research also finds that most inventions are *not* patented (Arundel and Kabla 1998, Cohen et al. 2000). On average, large European firms applied for patents on only 36% of product innovations and 25% of process innovations. Again, pharmaceutical firms are outliers—they applied for patents on 79% of pharmaceutical products.

{Figures 2 and 3 about here}

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12 See Lemley and Frischmann (2006) for an alternative view.

Also, it is not clear that the entry of imitators is necessarily detrimental to innovation as in the canonical reward theory model. If firms can obtain some rents even when competing against a limited number of other firms, then competition may actually increase innovation. As long as there is not too much competition, entrants may spur incumbents to not rest on their laurels (Aghion et al. 2005) and entrants may bring diverse knowledge that increases the odds of future innovation success (Bessen and Maskin 2008). Aghion et al. find that innovation is greatest when firms earn moderate rents; too much or too little competition reduces innovation rates. Gort and Klepper (1982) study the industry life cycles of a number of major new technologies. Most of these industries follow a pattern: beginning with only one or a few firms in the market, there is a phase of rapid entry of new firms. This is followed by a leveling off and a shakeout, reducing the number of firms and leading to a mature phase with a small number of dominant firms. They find that innovation rates, for both major and minor innovations, are greatest during the second and third phases when there is a lot of entry (see Figure 2). Less innovation occurs when firms face less threat of competition. On the other hand, *patenting* rates are greatest during the shakeout phase (see Figure 3). This suggests that much innovation is not dependent on patenting.

This evidence does not mean that patents have no value, rather, the effectiveness of patents varies by industry and technology and for many industries and technologies their effectiveness is limited. This assessment is supported by the estimates of the private value of patents discussed in the next section.

2.5 Estimates of the Net Benefit

It is possible to make more direct estimates of the incentives that patents provide to their owners. The gross private benefits of patents can be inferred from the value owners' place on their patents. And some of the major cost that patents impose on innovators can be inferred from

data on patent litigation. (More detail on both of these can be found in Bessen and Meurer, 2008, Chapters 5 and 6.)

Economists have used a variety of techniques to estimate the private value of patents to their owners. Some estimates are based on the observed behavior of patent owners, such as their willingness to pay fees to keep patents in force or their willingness to patent in multiple countries.[13] Other estimates are based on the contribution that patents make to the stock market value of public firms.[14] The good news is that these different methods produce estimates that roughly correspond. Not surprisingly, patent values vary tremendously depending on the industry. The average value of patents held by large pharmaceutical firms is easily an order of magnitude larger than the average value of patents held by firms in other industries.

Since the value of a patent can be thought of as the expected present value of the profit stream from the patent, the gross profits from a patent can be estimated by multiplying patent value by a rate of return, say, 15%.[15] These profits represent the stream of rewards that provide an incentive to invest in innovation.

However, patents may also impose disincentives on innovators. Litigation costs represent an important disincentive to innovation. A firm looking to invest in innovation will consider the risk that the innovation will inadvertently expose it to a patent-infringement lawsuit. Since infringement lawsuits are usually filed against firms exploiting new technologies, development of a new technology exposes the innovator to risk of inadvertent infringement if patent

[13] These studies include Barney (2002), Bessen (2006a), Putnam (1996) and Serrano (2005) using US data and Baudry and Dumont (2006), Lanjouw (1998), Pakes (1986), Pakes and Schankerman (1984, 1986) and Schankerman (1998).

[14] These studies, reviewed in Bessen (2006b) include Cockburn and Griliches (1988), Megna and Klock (1993), and Hall et al. (2005).

[15] To be precise, this is the value of patent rents earned above and beyond the profits that can be realized on the underlying invention by other means.

boundaries are hidden, unclear or unpredictable.[16] That risk weighs against the profits that can be made from innovation. Of course, firms are both patent holders and potential defendants, so a comparison of profit flows and litigation costs for a group of firms should reveal the sign of net incentives.[17] Several studies have estimated the expected cost of litigation using stock market event studies around the date of patent lawsuit filings.[18]

{Figure 4 about here}

Figure 4 shows a comparison of estimates of the profits and litigation risks from owning patents. The results in figure 4A show that chemical and pharmaceutical firms earn far more from their patents than they lose to litigation. But for other firms, figure 4B tells a simple but dramatic story: during the 1980s, these firms might have, at best, broken even from patents, but in the mid-1990s litigation costs exploded. By almost any interpretation, the patent system could not be providing overall positive incentives for these United States public firms by the end of the 1990s. The risk of patent litigation that firms faced in their capacity as technology adopters simply outstripped the profits that they made by virtue of owning patents. A firm looking to invest in an innovative technology during the late 1990s, taking this risk into account, would expect the net impact of patents to reduce the profits from innovation rather than to increase them.[19]

Note that patents do provide profits for their owners, so it makes sense for firms to get them. But taking the effect of other firms' patents into account, including the risk of litigation,

[16] For this reason, patent-infringement risk is not a general cost of doing business, but is specifically related to innovative activity. In fact, the risk of being sued increases with a firm's R&D spending. Of course, some lawsuits are filed against copyists, not inadvertent infringers. We argue elsewhere (Bessen and Meurer 2008, Chapter 6) that most costly litigation is associated with inadvertent infringement rather than piracy.

[17] Note that some, but not all, of the litigation cost to a defendant shows up as profit to the plaintiff patent holder. To the extent that litigation costs represent a transfer to the patent holder (this is not largely the case), these transfers are accounted for by estimates of patent value and the profit flow from patents.

[18] Studies of stock market reactions to patent lawsuits include Bessen and Meurer (2007), Bhagat et al. (1994), Bhagat et al. (1998), Haslem (2005), Lerner (1995) and Lunney (2004).

the average public firm outside the chemical and pharmaceutical industries would be better off if patents did not exist.[20]

3 The Bottom Line

The historical evidence, the cross-country evidence, the evidence from economic experiments and estimates of the net benefits of patents all point to a marked difference between the economic importance of general property rights and the economic importance of patents or intellectual property rights more generally. With the cross-country studies in particular, the quality of general property rights institutions has a substantial direct effect on economic growth. Using the *same* methodology and in the *same* studies, intellectual property rights have at best only a weak and indirect effect on economic growth.

The research also suggests a reason why patents differ from general property rights in motivating economic growth overall: the positive effects of patents appear to be highly contingent. Differences in technology and industry seem to matter a lot for twentieth century R&D managers and also for the innovative performance of nineteenth century world's fair exhibitors. Some results from the cross-country studies suggest that less developed countries have a harder time realizing benefits from patents or that countries that participate actively in international trade may benefit more.

Some of these differences arise because of differences in the relative costs and effectiveness of alternatives to patents. Patents may contribute more to economic growth in the pharmaceutical industry than they contribute in electronics industries because the latter can more effectively earn returns on innovation through lead time advantage, sales of complementary products and services, etc. Other differences may arise because of subtle differences in patent

[19] Preliminary data for more recent years suggest that this problem has gotten worse since 1999.
[20] The expected benefits exceed expected costs for small public firms, and this is probably also true for independent

institutions. During the nineteenth century, the US patent institutions performed differently (and perhaps better) than their British counterparts. Patents are likely to work better in the pharmaceutical industry because patents on chemical entities have much sharper boundaries than, for example, patents on software.

Of course, the economic effectiveness of all forms of property depends on details of the supporting institutions—this is evident from the disparate growth paths of Soviet Bloc economies. But the economic effectiveness of patents may be much more sensitive to the details of the relevant institutions than are general property rights. Perhaps this is because patent law may be much more specialized, complex and sophisticated than, say, real property law and, so, effective institutions may be more difficult to develop and maintain.

In any case, the empirical economic evidence strongly rejects simplistic arguments that patents universally spur innovation and economic growth. The direct comparison of estimated net incentives suggests that for public firms in most industries today, patents may actually discourage investment in innovation

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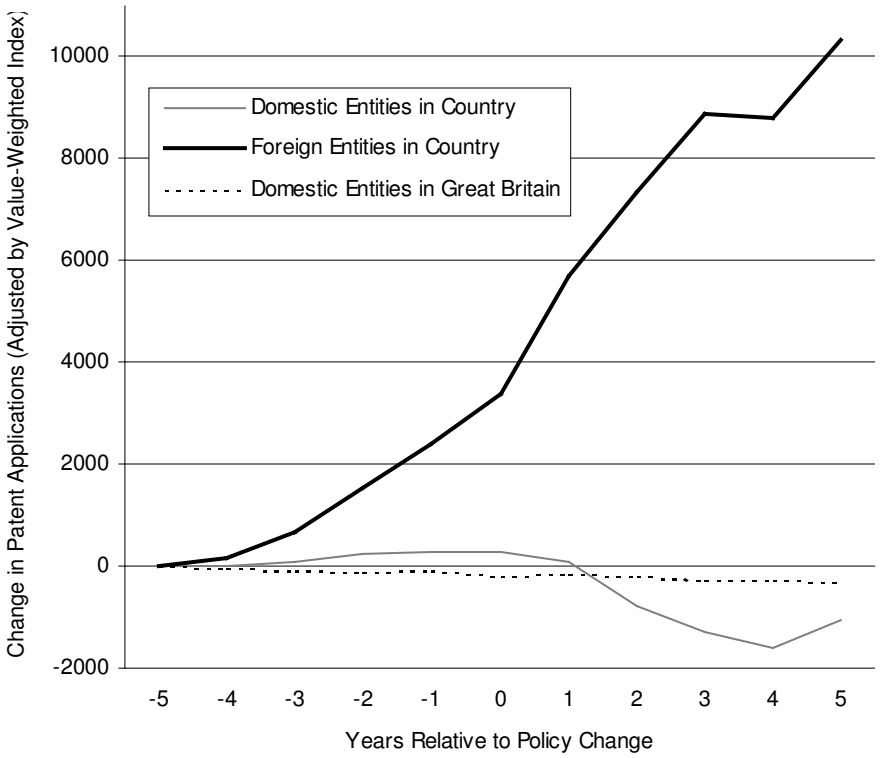
Figure 1. Change in Patenting around Patent "Strengthening"
Source: Lerner (2002)



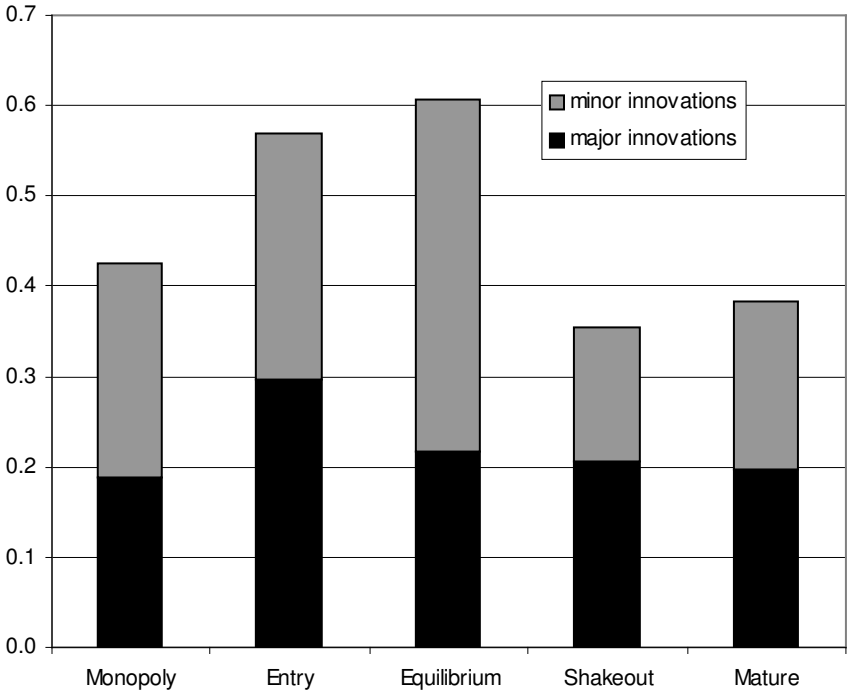


Figure 2. Rates of Innovation over Technology Life Cycle
Source: Gort and Klepper (1982)

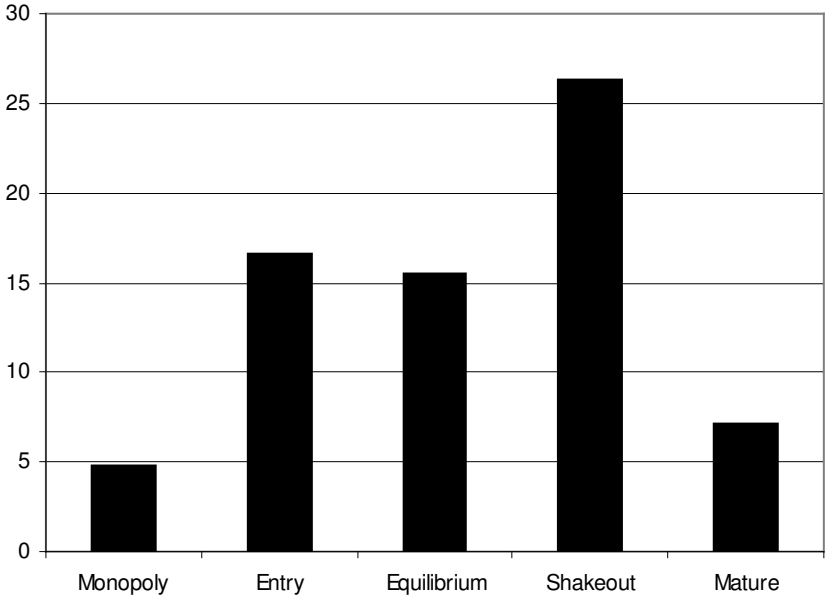


Figure 3. Patenting Rates over Technology Life Cycle
Source: Gort and Klepper (1982)

Figure 4. Aggregate profits from patents and aggregate litigation costs for US public firms
Source: Bessen and Meurer (2008)