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PATENTS AND PROPERTY

by

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Additional hard copies of the paper are available in Room 972LR
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1 A note to law school readers

I have attached this introduction and drafts of four chapters from a book I am writing with Jim Bessen. The intended audience for the book is academic lawyers, economists, and policymakers. Two of the attached chapters (2 and 6) are pitched for our intended audience, but another two of the attached chapters (“Patent Litigation with Endogenous Disputes” and “The Patent Litigation Explosion”) were written primarily for economists. We will revise those chapters to improve readability for non-economists. I have included the litigation chapters because I think you will be able to follow most of the material, especially in “The Patent Litigation Explosion.”

Audience members should read this introduction, and then read selectively from the attached chapters. Chapter 2 reviews previous economic research on the performance of the patent system. “Patent Litigation with Endogenous Disputes” develops a game-theoretic model of patent disputes; this chapter is the toughest read for non-economists (but it is quite short). “The Patent Litigation Explosion” searches for an explanation of the explosion in patent litigation over the last twenty years. We attribute the explosion to increased uncertainty in patent law. Chapter 6 reviews economic theories of property and compares them to economic theories of patent. The key message in this chapter is that patents will not perform as well as property if they lack the clear boundaries and possession rules found in property law.

2 An outline of the book

The Patent System is Broken

This book challenges the view that the economics of patents closely follows the economics of property. Economists generally agree that a strong system of property rights is critical to fostering growth in a market economy. Patent scholars who emphasize the property-like qualities of patents usually advocate a strong patent system, on the assumption that strong property rights over inventions are also good for economic growth. We argue that patents do not
work “just like property.” Patents do play some role in promoting innovation and economic growth, but that role is limited and highly contingent compared to the role played by traditional property rights. The effect of patents depends on the industry and technology; it appears to vary with the nation’s level of development; it may be highly contingent on the specific nature of the patent law and institutions. Above all, the ability of patents to spur innovation appears to depend heavily on the alternative means by which firms can profit from innovation. This means that policy-makers need a careful accounting of patent incentives and disincentives to invest in R&D across different industries, technologies, etc. In the first part of this book, we perform just such an accounting. We review the empirical research on patents and conduct several new econometric investigations of the performance of the American patent system.

We begin by estimating an upper bound for the value that different types of patent holders receive from their patents. The value of a patent should equal the extra profits that patent brings its owner. These profits might be generated as licensing royalties, if the patent is licensed, or they may be the extra profits the patent holder earns by excluding other firms from the market. These profits also represent an upper bound on the incentive that patents provide to invest in R&D.

This is an upper bound on the size of the incentive because patents may also impose costs on performing R&D. One source of costs arises when innovators cannot determine reliably whether a technology they want to develop infringes a patent. In this case, innovators cannot avoid patent disputes. But patent disputes are costly. Some end up in litigation, others are settled before a lawsuit is filed, but usually at some significant cost. To obtain a lower bound estimate of these costs, we estimate the litigation costs incurred by R&D performers.

The value of patents minus the expected cost of disputes provides an upper bound estimate of the net incentive that patents afford R&D performers. We calculate these incentives for different industries and different types of patent holders and we track these changes over time. Among our results we find:

1. Patents do provide strong positive incentives in the pharmaceutical industry, but in other industries, such as software publishing, the incentives are significantly negative.

2. The incentive effect is positive mainly for large, established firms. It is negative for startup firms. University inventors and independent inventors have small, but positive, incentives.
Twenty years ago, the aggregate incentives provided by the patent system were positive; by the late 1990s, the aggregate incentives were negative.

**Why Don’t Patents Provide Stronger Incentives?**

The empirical evidence suggests in some industries and at some points in time the patent system worked pretty well to encourage the development and diffusion of new technology. Why does it fail in other industries and at other times? We think a big part of the answer is that patent law is unstable. It changes a lot over time and across industries. When it drifts too far from the principles of traditional property law, it performs badly.

The second section of the book will present an economic analysis of property and compare it to an economic analysis of patents. Private property provides social benefits because it encourages investment, exchange, and the development of financial markets. In theory, patents should provide all of these social benefits, and more. But these social benefits only arise when patent rights are well-defined and when inventors actually possess the knowledge to practically apply their patented inventions. Indeed, the same can be said about tangible property. Property law succeeds because it specifies clear boundaries, and bestows rights on parties in possession of their property. We note the isolated cases in which property law fails to deliver social benefits, and we attribute the failure to fuzzy boundaries and problems assessing who possesses the property in question. We then move to a complementary assessment of patent law, and explain why patent law fails when boundaries are fuzzy and possession is uncertain.

We will show that the major principles of patent law that were developed during the nineteenth century are designed to make patent rights very much like property rights, to “propertize” these rights. The ban on patenting abstract ideas and the ban on patenting obvious inventions promote clear boundaries and increase the likelihood that patent holders are the sole possessors of their claimed inventions. At the same time, institutions developed that supported decentralized decision-making and exchange, including the patent examination system, networks of patent agents, and institutions to disseminate patent information. These institutions fostered the growth of a very active market in patents after the Civil War.

Unfortunately, during the last two decades, patent law has followed a variety of policies that make patent boundaries fuzzy and possession less certain. Claim construction is in turmoil,
patentable subject matter has expanded to include increasingly abstract ideas, and the non-obviousness requirement is falling into disuse. The Federal Circuit has shown some concern about fuzzy rights; it has pushed to restrict application of the doctrine of equivalents, and strengthened the written description requirement. These moves work against the trend toward greater uncertainty, but they are probably an inadequate response.

**Fixing the Patent System**

The third section of the book presents our agenda for reform of the patent system. Our key message in this section is that we are wary of piece-meal reform. The merit of many proposed reforms depends on how property-like the patent system really is. For example, many critics have called for better quality patent examination. We think better staffing at the Patent Office will do little to improve the patent system. How can more careful examination improve the quality of patents when examiners have only the vaguest idea what scope the Federal Circuit will ultimately assign to the claims they are examining?

Three other reforms call for more intense antitrust scrutiny of the use of patent lawsuits, procedural changes to encourage patent challenges, and reduction in the availability of injunctive relief to successful patent litigants. The three reforms are desirable ways to mitigated costs of fuzziness which leads to anti-competitive and opportunistic patent lawsuits. Whether these reforms are warranted depends on whether patent clarity can be increased. If reforms can be implemented that improve the clarity of claims and certainty of possession, then the case for the proposed reforms is weaker.

We explore a variety of patent law reforms intended to increase the clarity of patent rights.


Survey of Empirical Research: 
Do Patents Work as Property?

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 Similarly, the Intellectual Property Owners Association,
suggests that property-based incentives explain U.S. technological leadership: “The possibility of
patent rights gives incentives to inventors and their employers to create new technology and to
invest in commercializing technology. Policy makers have generally agreed that the American
tradition of strong patent laws has contributed to making this country the world's technological
leader, a position it has held for more than a century.”2

This is a seductive argument. 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, it might be that well-developed patent systems caused 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, 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. 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.

It may well be true, as the Intellectual Property Owners maintain, that most policy makers see a

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1 Mark Schultz. “The Ideological War over Intellectual Property,” Tech Central Station, 2005,
2 “Patent Brochure,”
link between “strong” patent laws and U.S. technology leadership. But as James Boyle acerbically notes, policy makers have too often ignored empirical evidence, basing policy, instead, on “faith-based” reasoning about property rights on such matters as software patents, broadcast rights, copyright term, and database rights. The problem with this sort of reasoning is that it is based on analogy: because property rights promote economic growth, then patents, which are like property, are assumed to promote economic growth and technological advancement as well. Patents are called “intellectual property,” but, as the previous chapter discusses, there are important differences between patents and traditional forms of property. Indeed, the term “intellectual property” only gained wide usage during the last two decades, and only recently has the term mostly shed the quotation marks that explicitly remind us of the analogy being made. Although patents share important features with tangible and financial property, the differences between them may critically affect the link between patents and innovation and economic growth.

On the other hand, not all policy makers ignore the evidence. At least one group of policy makers at the World Intellectual Property Organization has looked at the evidence and concluded, “Current data regarding the importance of IP [intellectual property] in economic development is still limited, however. Visible and demonstrable evidence of economic payoff attributable to IP protection is currently not sufficiently developed.” This assessment may be too pessimistic, but it does suggest that the empirical evidence about the economic effects of patents may be quite different from the evidence about property rights more generally.

This chapter surveys previous empirical research on the economics of patents, comparing this research to similar research on property rights. We reject the conclusion that the evidence is “not sufficiently developed” or that the evidence is inconclusive. Instead, there is a substantial and well-developed literature and we find clear and consistent evidence of private economic benefit from patents. However, the evidence also suggests that these benefits are limited in important ways, they depend on other factors and other institutions, and patents may also impose significant social costs. In short, patents are not just like property. Instead, the benefits of the patent system are much more qualified and our analysis provides some clues as to why this is so.

2 Comparing the evidence on property rights and patents

2.1 Historical Evidence

We look at three 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; and evidence from “natural economic experiments,”

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3 We assume that the IPO really means to say that strong patent laws make a substantial contribution to US technological leadership.
observing the impact of discrete changes in patent law.

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.7

One reason for 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). Richard Arkwright did patent his spinning technology, but that patent was invalidated. Arkwright 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. For one thing, Watt’s reputation appears to have been substantially hyped (MacLeod 1998). More important, Watt’s improvement only made a limited contribution to economic growth (von Tunzelman 1978).8 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 increase in efficiency can be attributed to “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. Patent litigation was costly and risky. Courts were not always sympathetic to patent holders, patent law was complex and patents could be

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7 Joel Mokyr (1999) reviews the literature, concluding “The exact role of the patent system in Britain’s Industrial Revolution is hard to determine.”

8 Boldrin and Levine (?) question whether Watt’s patent may have even held up further improvements.
invalidated on technicalities (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. Moreover, despite the costs of obtaining and enforcing patents, in many industries competitors could “invent around” patents, finding a non-infringing alternative. Thus it is not entirely surprising that Christine MacLeod (1988) finds that about ninety percent of patents arose in industries that saw little innovation, and that patenting was at best loosely related to technological innovation.

In contrast, the experience in the United States was quite different from that in Britain. The US initiated patent examination in 1836 and patent fees were quite low. When examination standards were relaxed in 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 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 technologies for many decades.

It may nevertheless be the case that the US patent system had a much more positive effect on innovation and economic growth than the British system had. 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 quantitative research on the effect of patents on innovation in different countries during the nineteenth century (2005). 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.

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. The multiple regression approach allows one to assess the extent to which property rights affect economic growth independently of other factors. A few studies have also used measures of a country’s patent rights and intellectual property rights, but 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 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. Again, the property variables show a strong relationship with economic growth.

Several studies have also included measures of patents or intellectual property rights, but the results are quite different. 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 (estimated with ordinary least squares) 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 (at a 1% level), 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

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9 They perform instrumental variable regressions, using instruments such as distance from the equator and the primary language of the country.
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 intellectual property rights (not just patents) 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 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. 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 that it appears 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, 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.

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10 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 patent institutions.
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 appeared to depend 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 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 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 regulatory 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 government and regulatory institutions to support the property system and these are often more difficult to develop.

If the devil lies in the details for general property rights, 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 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 drug patent extension in Italy in 1978. Italy had a well-established drug manufacturing industry, some of which made generic versions of drugs patented elsewhere. They found that drug R&D within Italy did not accelerate after the law change.¹¹ Lanjouw and Cockburn (2001) study the effect of the TRIPS treaty,

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¹¹ Italian firms did obtain more patents in the US after the change, but the authors attribute this to a change in the
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.

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 in substantive law that improved the scope or extent of patent rights and he also includes reductions in patent fees.\(^\text{12}\) 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

\(^{12}\) 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.
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.

3 Empirical Evidence on Free-Riding

Before we attempt to draw overall conclusions from this literature review, it is helpful to ask whether patents do, in fact, play the role prescribed for them in reward theory. Specifically, 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 aspects). 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. Imitators appear to have significant entry costs.

Also, perhaps the nature of pharmaceutical patents—patents on small, well-defined molecules—may affect the effectiveness of patenting in this industry. 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 appropriability are more effective than patents at 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.

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 2000). Aghion et al. find that innovation is greatest when firms earn moderate rents; too much or too little competition reduce 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 estimates of the private value of patents. We will discuss this research in depth in the next chapter, however, most studies find that the private value of patents is about 10-15% of the value of R&D spending. This is consistent with the survey results above—in most industries, most of the value of R&D is appropriated by means other than patents. Nevertheless, patents have substantial value and may play a critical role in protecting some innovations.

4 The Bottom Line

The empirical evidence we have surveyed does not portray patents as positively and unambiguously as some advocates might like. Some suggest that the deficiency may be in the data or in the methods used to analyze it. It may be, as WIPO suggests, that the evidence is just “not sufficiently developed.”

We argue, to the contrary, that the evidence is conclusive. We make two points. First, the economic effect of patents is distinctly different from the effect of general property rights on economic growth. Second, the evidence of this difference is consistent across a large number of studies using a variety of methodologies.

The historical evidence, the cross-country evidence and the evidence from economic experiments
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. Patents are not just like property rights. 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, 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 institutions. During the nineteenth century, the US patent institutions performed differently than their British counterparts. 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. Patent law is much more specialized and sophisticated than, say, real property law and so effective institutions may be more difficult to develop and maintain.

In any case, these differences mean that the economic effect of patents will be limited in scope, applying to different industries, different technologies, and different countries in varying degrees. Hence the overall effect will be uneven and weak.

This does not mean that patents are not or cannot be effective at spurring innovation and economic growth. But it does suggest that an accurate economic appraisal of the patent system needs to look carefully at these differences, separately evaluating the costs and benefits of the patent system across different technologies, industries, and other sub-groups, and then toting up the separate net benefits. This evaluation needs to consider the costs imposed by patents and the effectiveness of alternatives. This is what we do in the next several chapters.

But the empirical economic literature on patents strongly rejects simplistic arguments that patents are property and that, therefore, patents universally spur innovation and economic growth. “Property” is not a ritual incantation that blesses the anointed with the fruits of innovation; legislation of “stronger” patent rights does not automatically mean greater innovation. Instead, the effectiveness of patents depends on the details of the laws, institutions, technologies and industries involved. Our approach is to understand these differences and then draw out the implications for policy.
The Economics of Property Rights and Patents

The empirical evidence strongly suggests that patents do not always “work” like tangible property. They do not always deliver the same net benefits to society, nor do they spur economic growth and innovation as reliably. Why do patents work differently? Perhaps the laws, regulations, and institutions of the patent system are somehow ineffective. Perhaps patent law is implemented differently from property law so that some major costs offset the benefits. Or perhaps the analogy between patents and tangible property is inappropriate in the first place. After all, inventions have different economic characteristics from tangible products.

This chapter discusses the economics of private property. We look at the main features of property and how these features generate important social benefits. We ask whether patents share these main features and, if so, whether there are important differences in the implementation of the patent system that affect its ability to deliver similar benefits.

Of course patents are not the only way to protect returns to innovative effort or to encourage innovation. Private firms can protect their returns from innovation through lead time advantage or by selling complementary goods and services or other means. Governments can encourage innovation through R&D subsidies or prizes to inventors. There is even another form of “intellectual property” that protects inventions, namely, trade secrecy. We return to a discussion of these alternatives in a later chapter.

We begin by asking whether the analogy between patents and property is apt.

1 Are patents property?

Most people understand that patents are a type of property. The notion that inventors should reap the benefit from their inventions has great intuitive appeal. There is a complementary sense of outrage when the interests of inventors are trampled, especially when the villains are big corporations. Many scholars share these sentiments. Economists routinely treat patents as property rights. Even most lawyers who do not specialize in intellectual property readily accept the characterization of patents as property. It’s curious, then, that intellectual property law scholars are not completely comfortable applying the property label to patents.

Scholars critical of the recent expansion of intellectual property rights place part of the blame for the expansion on the rhetoric of property. They note that patents and copyrights have existed from the founding of the U.S. but the label intellectual property has become popular just in the last twenty years. Not so long ago, lawyers placed patent, copyright, trademark, and trade secret lawsuits in the category of business torts. Strangers owned certain duties under tort law toward intellectual property owners, but not the heightened level of deference usually owed to owners of real property.

Today there is a vigorous debate among intellectual property law scholars between those who generally approve of the propertization of intellectual property law, and those who don’t. For example, Mark Lemley claims “the economics of intellectual property law should focus on the economic characteristics of intellectual property rights, not on inapposite economic analysis borrowed from the very different case of land.” (Lemley, 2005). In contrast, William Landes and Richard Posner claim “there is a danger of losing sight of the continuity between rights in
Like Landes and Posner we think the economics of property has valuable lessons for the economics of patents, but unlike Landes and Posner we do not see a “continuity between rights in physical and intellectual property,” we think much can be learned about the relatively poor performance of the patent system by understanding the sources of discontinuity between physical property and patents. We start by comparing the main features of property and patent law.

Use and Exclusion

The right to use and exclude use by others are the hallmarks of tangible property under the law. An owner has the right to wear his shirt and live on his land. He also has the right to exclude others from use of his shirt and his land. Thus, property law gives an owner rights against strangers. In contrast, contract law creates rights only between parties who assent to be bound by the law. Patents are like property in that they create rights to exclude use by others, including strangers.

Patent law departs from tangible property law by granting only the negative right to exclude and not the affirmative right to use an invention. This distinction matters when someone invents a patentable improvement or a new use of a currently patented invention. The second inventor can get a patent on her invention but the patent is subservient to the patent on the earlier invention. In other words, the second inventor cannot lawfully use her invention unless she gets permission from the owner of the patent on the first invention. Symmetrically, the first inventor also cannot use the second invention unless he gets permission from the owner of the patent on the second invention. Thus, there is a blocking relationship between the two patents — no one has the right to use the second invention. Typically, this impediment to use is overcome through assignment or licensing arrangements.

Patents share another crucial feature with tangible property: liability does not depend on a defendant’s knowledge or intent. A trespasser is still liable regardless of whether she was mistaken about a property line or took care to avoid trespass. Similarly, a technology adopter is still liable for patent infringement regardless of whether she independently invented, or made a good faith effort to avoid intruding on someone's patent rights.

Neither tangible nor patent property rights offer absolute rights of exclusion. The pattern of exceptions is complicated, and on the whole quite limited. Two leading examples are: (1) the U.S. government can take tangible property or patents if it pays compensation; and (2) property owners may lose the right to exclude if they “sleep on their rights.”

Division and Transfer

Property rights are the cornerstone of a market economy. Property law supports exchange by allowing property owners to divide and transfer their rights. Patent law follows tangible property law in this regard, in fact, patent law arguably goes further to promote exchange than tangible property law.

Owners of tangible property can sell, divide and sell a portion, or rent their property. Thus, Hertz owns a fleet of cars that it rents for a period of time and then sells. Similarly, patent
owners can sell, divide and sell a portion, or rent their patent rights. In patent law jargon, a sale is called an assignment, and rental is called licensing. The rental to licensing parallel is not exact because the inexhaustible quality of information means that a patent owner can license multiple users without degrading the use value of the information; this is not possible with rental cars.

Sales and rental contracts may contain conditions that restrict permissible use of the tangible property. For example, a car rental agreement prohibits the renter from using the car recklessly, and typically sets payment terms that influence the distance driven and locations visited. Patent assignments and licenses may contain similar restrictions on permissible use of the patented invention. For example, a patent license may impose geographic, quantity, field of use, and even pricing restrictions on the licensee. Patent law is more generous to an owner than tangible property law in the sense that antitrust regulation of contract terms is relaxed in the context of patent licenses. Therefore, actions that a patent owner takes that might inhibit competition are more likely to survive antitrust scrutiny when they are linked to a contract involving a patented invention than to a contract involving unpatented tangible property.

**Scope and Duration of Rights**

Patents and tangible property display significant differences in terms of duration and scope. The property right in land is perpetual, personal property rights last as long as the property, but the patent right is generally limited to twenty years. The scope of tangible property is relatively easy to define in terms of physical attributes. For example, the scope of land rights is defined by a boundary traced on the earth. Defining the scope of patent rights is extremely difficult, because it is hard to draw a boundary around an idea. Below we will explain the difficult and uncertain process used by courts to construe the claim language in a patent and determine the scope of a patent.

**Acquisition and Ownership**

The rules of acquisition and ownership are similar for patents and tangible property, but the practical significance of acquisition rules is dramatically greater in patent law. Tangible property and patents can be acquired through a properly conducted sale or assignment by a previous owner. Legal disputes usually focus on the integrity of the chain of title. Tangible property and patents can also be newly acquired from "the state of nature." Naturally, newly manufactured personal property is owned by its maker. Other new personal property that is captured, harvested, or extracted from the public domain usually belongs to the person who first took possession of the item.

The rules governing acquisition of patent rights are complex, but essentially the first inventor is entitled to a patent, and subsequent inventors of the same invention get no rights. Patent law contains a significant limitation on acquisition missing from the law of tangible property: not all inventions are patentable. An invention must be new, useful, non-obvious, and fall into one of the appropriate subject matter categories. Furthermore, an inventor can spoil his right to a patent by choosing to exploit his invention as a trade secret, in which case the next inventor may be able to patent the invention.
Remedies

The final major feature of property is the generous set of remedies available to an owner whose property rights have been violated. Most notably, courts are quite willing to award injunctive relief and disgorge the defendant’s profits arising from the violation.\(^1\) In contrast, in contract law, injunctions are rare, and the usual damage measure awards the plaintiff his expected payoff, and usually will not force disgorgement of the defendant’s profit. Patent law also favors injunctive relief, but is not so generous with damages, and comes closer to the contract law approach to damages. Copyright law follows tangible property law and allows disgorgement of profit, and patent scholars have recommended that patent law should to.

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In summary, patents do seem to share many of the key features of tangible property. A patent owner can exclude others from using his invention. Patent infringement claims are effective against strangers, even if they are innocent, even if they independently invented the patented technology. Infringement lawsuits are backed by the threat of injunction. In addition, patent law has rules of acquisition, ownership, division, and transfer that are patterned after the comparable rules from tangible property law.

There are some differences between patents and tangible property. Patent law offers weaker rights than property law along four dimensions. First, patents are limited to twenty years. Second, there is no affirmative right to use a patented invention. Third, patent law only reaches inventions that are new, useful, non-obvious, and the proper subject matter. Fourth, patent damages do not include a defendant’s profit.

Patent law offers stronger rights than property law along two dimensions. First, patent owners have more freedom in their design of contracts because of a limited antitrust immunity. Second, patent law supports a variety of indirect forms of liability that allow the patent owner to bring suit against parties above and below the direct infringer in the value chain. Specifically, a patentee can sue an input supplier who contributes to inducing a customer to infringe a patent. Also, a patentee can sue anyone who buys or uses a patented product that was made by an infringing manufacturer. Indirect theories of liability are not so well-developed or important in tangible property law.

These doctrinal discrepancies are interesting, and we will comment more on them later, but, as we shall see, the truly significant differences between patents and tangible property are not linked to differences in doctrine, but to differences in application. Certain operational features of the patent system make patent rights much less clear than tangible property rights. But this is getting ahead of our story. To understand the economic significance of these differences, we must first explore the ways that the main features of property can generate substantial economic advantages.

2 Social benefits of property rights

2.1 Investment Incentives

Investment incentives are an easily recognized benefit provided by private property rights. Secure ownership of property assures an owner that he will appropriate a significant share of the return on his investment. For example, a farmer would be discouraged from cultivating crops on his land if his neighbors were free to harvest and consume his crops. If he can exclude others from the harvest, he can capture the market value of the crop, bolstering his investment incentive. Private property rights mean that the farmer’s crop is secure from expropriation by other private parties and, under normal circumstances, secure from government expropriation as well. It also means that the farmer gets the full value he can realize from consuming or selling his crop. Under other property regimes, such as feudalism and collective ownership, investment incentives are dampened because the farmer can not be sure to capture much of the return from his investment.

Several of the features of property identified above contribute to securing these returns on investment. Obviously, the right to exclude others, backed by strong remedies like a quick and effective injunction, enhances the security of a property owner. Less obviously, clear boundaries for property rights minimize wasteful disputes and reduce any uncertainty about the farmer’s claims to the crops. And the rules of acquisition ensure that a putative property owner is suitably positioned to make socially desirable investment decisions — an owner must show some degree of control over goods acquired from nature in order to claim them as property. This last point requires elaboration.

Clear possession rules mitigate concerns about premature or redundant investment by parties who are competing to acquire property rights. In the next section, we will discuss the copper mine “war” in Butte, Montana. We will explain that vague rules governing the scope of mineral rights newly acquired on federal lands lead competing mining companies to make nearly duplicative investments in tunneling, and wastefully speedy extraction decisions in a race to be the first to take possession of the contested copper ore.

2.2 Transfer to Higher Value Users

The second benefit of private property is so intuitive and fundamental that it sometimes goes unnoticed by non-economists: private property rights promote exchange. Private property regimes allow owners to alienate or sell their property. The market economy facilitates efficient trade and reallocation of property from a seller with a lower value to a buyer with a higher value from use of the property.

Property law also encourages transactions, and complements contract law in less visible ways. Property rights can be divided and transfers can be made contingent. Lawyers think of property as a bundle of rights, they often unpack these rights and design complicated transfers involving a subset of the rights in the package. The use of property as collateral to secure a loan is an example with particular relevance to patents and innovation. Such complex transactions are much more difficult in regimes without private property.

In another vein, property rights encourage information disclosure during contract negotiations. To see why suppose Alan has gold nuggets in a stream on his land. Suppose it
would be efficient for him to sell the land and let someone else extract the gold. Given insecure property rights, Alan would be reluctant to disclose his private information to Bonnie, a potential buyer. If the negotiations break down Bonnie might try to steal the nuggets or sell the information to a third party. Secure property rights make it profitable for Alan to disclose the information, and this disclosure promotes efficient transfer.²

2.3 Financial Markets

Economic historians and growth economists tend to define private property rights broadly enough to include partnership and corporate law. They suggest that financial markets are one of the mechanisms through which secure property rights promote economic growth. (Rosenberg ?) In particular, mortgage and similar laws increase the liquidity of financial markets by drawing wealth from real property owners, wealth that remains locked-up in less developed economies. The existence of partnerships and corporate entities relaxes liquidity constraints and risk-bearing costs on new ventures and encourage entrepreneurship. The rule of law plays a critical role in assuring passive investors that their ownership rights will be respected by those in control of a business.

2.4 Alternatives to Private Property

Private property is not absolutely necessary to achieve the social benefits described above. There are other ways that, say, a farmer can secure a full market return on his investment. He might use private protective measures like guards and fences to protect his crops. Perhaps social norms could also provide a secure environment for investment without property rights. For example, miners’ protective leagues formed in western U.S. mining communities that lacked effective law enforcement in the early days of the gold and silver rushes. The protective leagues effectively used force and promoted social norms to protect the mineral rights of miners. In a contemporary example, Robert Ellickson studied Shasta County, California, during the 1970s and he found that social norms largely displaced property law as the tool regulating stray livestock. When stray livestock caused property damage, the ranchers in the community relied on local norms to fix liability and enforce compliance. Ellickson found this homegrown regulatory regime systematically departed from the liability rules of California property law. Thus, the ranchers effectively opted out of property law for these disputes.

Beyond investment incentives, formal property rights are not a necessary predicate to flourishing exchange. There is evidence of exchange between tribes of hunter gatherers going back thousands of years before agricultural civilization [Seabright]. Such exchange was likely facilitated by social norms of reciprocity and by private sanctions. Even today, criminals engage in many forms of commerce without the benefit of state-sanctioned property rights using private enforcement to secure transactions.

So the economic advantage of private property must be measured relative to these alternatives. An interesting question is whether a well-designed private property system significantly increases social benefits compared to a system that relies solely on the combination of private policing and social norms to protect property? There are two reasons to think the

answer must be yes. First, public enforcement is often more efficient. There are fixed costs and economies of scale in setting up a police force. It is far more efficient to provide a single police force for an entire county than for each farmer to create his own private force.

Second, public enforcement can reinforce social norms. Well-implemented property rights are self-policing. Because the boundaries are clear, perceived as fair, and the remedies are swift and strong, tangible property rights are almost always respected without requiring expenditure on protective measures or enforcement. Only rarely do farmers actually go to court to prevent neighbors from stealing their crops. [Example.]

Property rights can be inexpensively enforced because they combine the threat of government force with social norms that support respect for property rights. On the other hand, social norms, enforced only with less effective private sanctions, can break down, leading to “tragedies of the commons.” For example, norms limiting catches in certain New England fisheries broke down and a commonly-managed resource was over-fished to the point of near-extinction for several species. Despite the occasional instance where commons are effectively managed [Ostrom], well-implemented property rights provide important incentives for investment in many cases.

3 Why does property sometimes fail?

Clearly, the ability of any property system — either for inventions or for other sorts of property — to deliver these benefits depends on the details of the statutes, case law, regulations and supporting social institutions. Each of the economic benefits of private property described above depends on fast, efficient enforcement reinforced by social norms. If the property system fails to provide these things, then property can fail on its own terms.

This section considers some of the ways property systems have failed and some of the ways they are designed to avoid failure. Then, in the next section, we consider how patents might stack up against property, both in the kind of benefits patents deliver and the ways in which patents might fail.

3.1 Fuzzy and arbitrary rights

A regime of private property creates administrative, clearance and enforcement costs. There are public and private costs of maintaining accurate information in registries. Property owners take steps to identify their property: surveying and fencing land, branding livestock, and fixing serial numbers on personal property. Third parties bear the costs of identifying property rights and obtaining permission to use private property. Occasionally, ownership or use rights are disputed and parties litigate to clarify property rights.

Property law takes steps to minimize these direct costs. It reduces the informational burden on the courts and litigating parties by favoring injunctive remedies. Damage remedies require expensive property valuations that can be avoided by reliance on injunctive relief.3 Informational benefits also flow from constraints imposed by the law on the forms of property and the ways

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3 Henry E. Smith, Property and Property Rules, 79 NYU L. Rev. 1719-1798 (2004). This benefit might be offset by a negative effect on bargaining in the shadow of property law. There is a lively debate between those who argue that damages lead to more efficient contracting and use of property. See, e.g., Ayres, Kaplow & Shavell. The traditional view is that injunctive relief leads to greater efficiency.
that property rights can be created. The constraints might reduce the burden on strangers to a property who must be able to recognize a property right and discern its boundaries.\(^4\) The constraints might also reduce the informational burden on those who wish to contract with a property owner.\(^5\)

If these constraints are not adequate or are poorly designed, then the informational burdens may cause property to fail to provide secure returns on investment and trade. If enforcement is uncertain, either because the boundaries are unclear or the legal status of title is ambiguous, then property may not work. For example, the transition from Mexican to U.S. rule in California disrupted property rights in agricultural land, and provided an important natural experiment for testing the investment incentives of secure property rights. Karen Clay [cite] explains that property rights were extremely uncertain in the 1850s and 1860s because of the change in government and the “widespread squatting on agricultural land held by the owners of Spanish and Mexican land grants.” She finds this adversely affected agricultural productivity. Also, the ambiguous status of property claims undermined the social norms supporting those claims, leading to lawlessness and violence.

Similarly, corruption and cronyism can make enforcement more costly or arbitrary and, at the same time, undermine social support for property rights. This, in turn, undermines the self-policing of property, requiring more costly overt enforcement. There is some econometric evidence [cite] showing these factors have played a role in the divergent growth paths taken by post-Soviet economies discussed above.

Even if property disputes are ultimately resolved in a clear and non-arbitrary fashion, the ability of property to deliver secure returns on investment may be undermined if the resolution of these disputes proceeds too slowly or if the boundaries are not initially clear. This was dramatically illustrated by mining disputes in the second half of the nineteenth century.\(^6\)

There were three different kinds of mining which yielded different kinds and frequencies of disputes because of differential information and enforcement costs. The California Gold Rush was dominated by placer claims in which deposits were largely found on the surface in a fixed location. [Lueck, Libecap] The mining camps set rules defining relatively small and clearly defined claims. Disputes were not too severe even though the mining camps were initially outside the reach of the law.

A different set of rules emerged for oil and gas rights because these minerals are migratory, that is, each well in a field draws from the same reserve that can flow from one location to another. Here it was impossible to enforce rights based on surface claims. Property rights granted to the underlying reserve based on surface claims could not be efficiently delineated and enforced. Instead, property rights were tailored to cover only the oil and gas drawn from the ground (so-called “rules of capture”) rather than the underlying reserve. This rule of capture creates a tragedy of the commons, and owners have an incentive to extract the mineral too rapidly. To combat this problem states developed regulations to limit the number of wells and to encourage “unitization” of the reserve where owners of surface claims shared jointly in the profits from the entire field.

\(^5\) Henry Hansmann & Rainier Kraakman.
\(^6\) Libecap, p.46 (between 1861 and 1866 leading mines spent 11% of total production costs on litigation)
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Claims to veins of minerals create a hybrid case, where surface claims can not entirely avoid costly disputes and the tragedy of the commons may occur, even when miners hold fairly broad rights. A remarkable example is the War of the Copper Kings in Butte, Montana. The mountain standing outside of Butte was once known as The Richest Hill on Earth. It was mined for gold, silver, and most notably copper. The early miners at Butte exhausted the relatively small supplies of gold and silver in the 1860s and 1870s. At that point four large mining interests began to buy old claims in a search for copper ore. By the mid-1880s it was becoming clear that the mountain was laced with a rich tangle of veins of copper that penetrated deep into the mountain. It was very difficult to trace the copper veins to the surface of the mountain. As a result, it did not become clear until about twenty years later who owned what copper.

Glasscock explains the source of uncertainty:

The federal mining laws … protect[ed] the prospector who first located an outcropping mineral vein. Such surface indication of valuable ore was known as the apex of the vein. The owner was guaranteed the right to follow that vein downward, even when it led under the holdings of claims located behind it. That would have been fine if veins were always continuous from the surface down, but too frequently they are not. They are broken or faulted, cut off here and elsewhere by worthless rock. If a vein leading down from the surface is lost near the vertical side wall of a claim, and a similar vein of identical ore is found below it or to one side in the adjoining claim, who is to decide whether the second discovery is a geological continuation of the first? Who but the courts, basing decision on the expert testimony of geologists and engineers?"

The interlaced veins meant that different mining companies often dug tunnels beneath or beside the tunnels of their rivals. Occasionally, miners would break through into a neighboring tunnel. Reno Sales reports of gun fights and chemical warfare in the mines. Sales and Glasscock both suggest malicious blasting by one mining company injured miners in other mines. Glasscock reports that one company would develop its claims so that the water in its mines would drain into rivals’ mines. Both Sales and Glasscock report that the mining companies would use inefficient extraction methods in their race to mine a contested vein before their rival was able to. Legal control over these socially harmful tactics was difficult because ownership was unclear, litigation was protracted and costly.

These varied mining examples show that the effectiveness of property rights is sensitive to the details of implementation. The benefits of private property derive from the promise of efficient, non-arbitrary enforcement. The details of the rules of acquisition and the determinants of the scope of the rights affect this efficiency. Poorly designed rules of acquisition, ownership and scope can cause property to fail. Below we look at how the rules determining patent scope and acquisition fare.

These failures are failures of property rights on their own terms—property rights fail to deliver on their promise of efficient enforcement to make investment and trade secure. But some scholars argue that property rights can, in a sense, work too much

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8 “Tens of millions of dollars were spent in litigation on this issue in the effort to determine the apex and consequent ownership of ore bodies in the Comstock Lode. Millions were saved by a consolidation of Goldfield properties to avoid such battles in the courts.” Glasscock. But in many areas, lode claims were limited by local constraints on sub-surface claims to reduce these inefficiencies [Gerard 1998, p. 257].
investment or give too many people rights, generating substantial social costs.

### 3.2 Rent Dissipation and Fragmentation of Rights

Two social costs of property can be attributed to property working “too well.” The first is socially wasteful rent dissipation that arises as parties race to possess unclaimed property. The second is the fragmentation costs that arise when property has been divided too finely. Rent dissipation arises because the acquisition rule awards property (or a patent) to the first possessor. From a social perspective the identity of the winner of the race is immaterial, but of course it makes all the difference to the contestants. Well-known social costs flow from socially excessive and duplicative acquisition investments.\(^9\)

Another cost arises from an excess of a different sort. Generally, property law encourages people to divide, transfer, and recombine property interests to suit their preferences. Sometimes the process of division goes too far, and it becomes difficult to transfer and recombine property rights efficiently. This is the problem of fragmentation. Property law takes certain steps to discourage fragmentation. Michael Heller coined the term anti-commons to describe high levels of fragmentation that frustrate both transfer and use of property.\(^10\) Use is discouraged when set up costs for uses are high compared to the value of the property; investment may be further discouraged if the fruits of investment spillover to the owners of neighboring fragments. Transfer is discouraged by transaction costs and hold-out problems. If fragmentation is less severe, the complementary nature of neighboring fragments causes social harm associated with a complementary product oligopoly. Economists have long-recognized that complementary oligopoly leads to prices above the monopoly price; and the associated output restriction grows more severe as the number of fragments grows.

Heller illustrated the tragedy of the anti-commons by pointing to Moscow storefronts during the transition away from central planning. He noted that storefronts stood empty in the Moscow winter even though retail trade flourished in kiosks on the streets in front of those stores. He explained that store leases were too costly because the ownership of any one store was fragmented. A retailer needed to arrange a lease with too many distinct property owners. The resulting transaction costs made such leases uneconomical.\(^11\)

Property law discourages harmful fragmentation through various rules. Heller discusses several of these rules including primogeniture, limits on future interests, property taxes and registration requirements, and zoning and subdivision restrictions.\(^12\) When land was the main source of wealth, landowners devised complicated schemes for distributing their land to their heirs. Besides dividing the land geographically, they often divided ownership rights over time and included contingencies linked to births and deaths of potential heirs. Primogeniture was a

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\(^9\) Government regulation and private ordering sometimes achieve coordination in search and acquisition efforts that avoid these costs. Also, the costs are small if contestants search in disjoint parts of the commons, perhaps because of different skills. Finally, search may be under-provided if dry holes are publicly observed and provide socially valuable spillovers.


\(^11\) He also notes that the Homestead Act prevented consolidation of land grants that were too small to be farmed economically, and the owners simply abandoned the property. Michael A. Heller, *The Boundaries of Private Property*, 108 Yale L. J. 1163, 1172 (1999).

feudal rule that restricted inheritances of land to the oldest son. The rule was intended to preserve
the feudal order but it also had the affect of preserving large estates. The common law of
England and the U.S. abandoned primogeniture but developed other more subtle doctrines to
regulate temporal fragmentation and weaken the grip of “dead hand of the past” on transactions
by the living. Property taxes and registrations fees obviously discourage fragmentation when the
fixed minimum taxes or fees are large relative to the value of the property. The registration fees
in the Federal Land Policy and Management Act forced the abandonment of stale mining claims
prevalent on federal lands. Finally, minimum lot size and setbacks requirements prevent the land
in residential neighborhoods from fragmenting too much.

*   *  *

The problems of rent dissipation and fragmentation might be very important for patents. However, our empirical analysis that follows will focus, instead, on the first set of questions, namely, whether patents encourage investment and trade by efficiently enforcing rights. Our reason for narrowing our focus is practical: it is difficult to measure rent dissipation and transaction costs. On the other hand, we can obtain reasonable estimates of the private value that patents provide their owners from investment or trade and we can estimate some of the costs of enforcement. Moreover, if patents fail to provide efficient enforcement, then problems with rent dissipation and fragmentation will be of secondary significance.

4  Patents as Property

4.1  Investment, trade and financing of inventions

4.2  Problems of scope, information and enforcement

[Under construction!]
Patent Litigation with Endogenous Disputes

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Patent Litigation with Endogenous Disputes

By James Bessen and Michael J. Meurer*

The recent explosion of patenting and patent disputes has sparked a growing literature on the economics of patent litigation. Generally, models in this literature take the existence of a dispute as given. This assumption is troubling because it hampers the interpretation of empirical studies of patent litigation and the assessment of many patent policy reforms.

Disputes would not arise if all technology adopters obtained ex ante licenses from patent owners. This suggests that two stories could explain the origin of patent disputes. In one, the technology adopter observes a patented technology, but chooses to imitate, “inventing around” and/or hiding the infringement. In the other, the adopter develops its own technology and is unaware of another firm’s putative patent rights. This kind of innocent infringement occurs because patent rights often have uncertain boundaries or questionable validity. In addition, the sheer number of patents facing a typical innovator makes careful assessment quite burdensome. Furthermore, patent claims are often hidden (sometimes strategically) until after firms have sunk technology investments.

These two accounts suggest that a model of disputes should consider: the decisions of patent owners to invent, to patent, and to monitor use of the patented technology by others; and the decisions of potential infringers to monitor extant patents, and develop and adopt new technology. Claude Crampes and Corinne Langinier (2002) endogenize disputes by focusing on a patent owner’s monitoring activity and imitative behavior by potential infringers. Our model includes this behavior, but it also includes defendants who “invent around” a patent, and defendants who are unaware of the patented technology. We find that this richer model generates testable implications that better match empirical evidence on patent litigation.

I. A Model of Patent Disputes

Our model (fully described in our working paper Bessen and Meurer (2006)) embeds a standard model of patent dispute resolution based on Meurer (1989), in a framework with early-stage patent and development investments by a patent owner and a potential defendant. The model has three stages. In stage one, firm 1 chooses an investment, $P_1$, in patent “refinement.” We assume firm 1 has an exogenously given invention, and chooses a level of patent protection that influences the probability (actually a distribution of probabilities) of successfully suing firm 2 for patent infringement. Firm 1 can “refine” its patent protection to improve its probability
distribution by obtaining multiple patents, delaying the issuance of some of its patents through
continuation practice, crafting multiple claims, investing in high quality claims and disclosures,
conducting a careful prior art search, and also by monitoring the activities of firm 2. We assume a
constant marginal and average cost of refinement, \( \rho \). In stage two, firms 1 and 2 simultaneously
choose development investments, \( x_1 \) and \( x_2 \). We assume a constant marginal and average cost of
development, \( \delta \). In stage three, the firms decide whether to dispute infringement and if so, they
then decide whether to enter a license agreement or file a lawsuit.

We assume the firms hold symmetric information throughout the game. Between stages
two and three, the firms observe the probability \( \alpha \) that firm 1 could win an infringement suit
against firm 2. At the earlier stages the firms know that \( \alpha \) is distributed over \([0, 1]\) according to
the distribution function \( F(\alpha; P_1, x_2) \). We assume that \( P_1 \) and \( x_2 \) induce shifts of \( F \) that satisfy first
order stochastic dominance. It is natural to assume that \( P_1 \) and \( x_2 \) influence the distribution \( \alpha \). A
patent dispute only arises when firm 2 adopts a technology that arguably falls within the scope of
at least one of firm 1’s patents. Firm 1 can improve its prospect at trial by investing more in
patent refinement which shifts the distribution to the right, and firm 2 can affect its prospect at
trial through its development investment. Possibly, firm 2 increases its exposure to a lawsuit by
increasing it development investment; alternatively, firm 2 might reduce the probability of a
successful suit by developing around the claim language in firm 1’s patents, or by hiding its
infringement. For now, we leave open the possibility that \( x_2 \) shifts the distribution either right or
left.

In stage three, there are four possible outcomes:

1. Firm 2 observes \( \alpha \) and decides to abandon its newly adopted technology
(“deterrence”). Firm 1 gets a monopoly payoff \( M(x_1) \) and firm 2 gets zero.

2. Firm 2 does not abandon the technology, but firm 1 does not assert its patent
(“acquiescence”). The firms get duopoly profits \( D_1(x_1) \) and \( D_2(x_2) \) respectively.

3. Firm 1 asserts its patents and the firms bargain to a settlement. The payoffs are Nash
bargaining solutions, \( S_1 \) and \( S_2 \). Let \( \Sigma(\alpha, x_1, x_2) \) denote the joint profit from settlement, \( \Sigma(\alpha, x_1, x_2) = S_1 + S_2 \). Development investments could spill-over to raise the joint profit from settlement, but
in the basic model we assume they have idiosyncratic value to the investor.

4. If bargaining breaks down, the firms litigate with payoffs \( L_1(\alpha, x_1) \) and \( L_2(\alpha, x_2) \). Firm 1
may sue because it gains advantages including: (a) a reputation for litigiousness, (b) avoidance of
settlement cost, such as dissipation of rents under settlement; and (c) enhanced exclusionary value
of a successfully litigated patent.
Naturally, the litigation payoffs depend on the probability that the patentee wins the lawsuit. We also allow the settlement payoffs to depend on this probability, because the rigor of antitrust regulation of patent licenses depends on the strength of the threatened patent suit. At one extreme, simple prosecution of a patent lawsuit can lead to antitrust liability if the suit is baseless. Also, output restrictions negotiated under the cover of sham patent licenses have resulted in antitrust liability. At the other extreme, courts have shown extreme deference to licenses involving strong patents. In particular, we assume that\[
L_1 + L_2 > M_1, D_1, \text{ and } D_2, \text{ are independent of } \alpha. \text{ This condition is required for equilibrium litigation and is consistent with our explanations above.}^{1}
\]

**II. Settlement, Lawsuit, Acquiescence or Deterrence**

We find a subgame perfect Nash equilibrium by analyzing backwards through the three-stage game. In general, there are four solution regions as shown in Figure 1. The solution boundaries between these regions are:

1. \(a_A\) solves \(L_1 (\alpha) = D_1\). When \(L_1 < D_1\), firm 1 lacks a credible threat of litigation and we assume that antitrust restrictions prohibit settlement, leading to acquiescence.\(^2\)

2. \(a_L\) solves \(L_1 (\alpha) + L_2 (\alpha) = \Sigma (\alpha)\). For \(\alpha \in [a_A, a_L]\), both parties have a credible threat of suit, and the parties reach a license with \(S_1 = (\frac{1}{2})(\Sigma + L_1 - L_2)\), and \(S_2 = (\frac{1}{2})(\Sigma + L_2 - L_1)\). For \(\alpha \in (a_L, a_D)\), a lawsuit is filed, firm 1 earns \(L_1\) and firm 2 earns \(L_2\).

3. \(a_D\) solves \(L_2 (\alpha) = 0\). For \(\alpha \in [a_D, 1]\), the alleged infringer cannot credibly defend a suit and drops out.

Given our assumptions we have unique solutions such that, \(0 < a_A < a_L < a_D < 1\).\(^3\)

Figure 1 also displays the third-stage profit \(V_1\) for each firm as a function of the probability of a successful lawsuit \(\alpha\). As might be expected, a stronger patent suit helps firm 1 and hurts firm 2; the profit of firm 1 weakly increases in \(\alpha\), and the profit of firm 2 weakly decreases in \(\alpha\).

[Figure 1. Solution Regions about here]

**III. Patent Refinement and Development Investment**

At stage one when firm 1 makes patent investments and at stage two when firms 1 and 2 make simultaneous development investments, they believe the strength of a potential patent lawsuit by 1 against 2 has a probability distribution \(F(\alpha; P_1; x_2)\). The firms look ahead to stage
three using $F$ to calculate the expected payoffs given acquiescence, settlement, litigation or deterrence. The expected profit for each firm is:

$$
\pi_1(x_1, x_2, P_1) = \int_0^1 V_1(\alpha; x_1, x_2) dF(\alpha; x_2, P_1) - \delta_1 x_1 - \rho P_1
$$

$$
\pi_2(x_1, x_2, P_1) = \int_0^1 V_2(\alpha; x_1, x_2) dF(\alpha; x_2, P_1) - \delta_2 x_2
$$

Recall $V_i(\alpha)$ denotes the profit to firm $i$ at stage 3, marginal cost of development is denoted $\delta_i$, and marginal cost of patent refinement is denoted $\rho$. The analysis in our working paper provides conditions on $F$ sufficient to guarantee a unique subgame perfect Nash equilibrium in which $x_1$ and $x_2$ are strategic substitutes.

**IV. Testable Implications of the Model**

Our model of patent disputes generates a variety of comparative static results that we investigate empirically in Bessen and Meurer (2005). Consider two randomly selected firms. What determines the probability that one will file a lawsuit against the other? The probability of litigation is $\lambda = F(a_D; P_1, x_2) - F(a_L; P_1, x_2)$. Referring to Figure 1, this is the portion of the distribution $F$ that falls between $a_D$ and $a_L$. Generally, two sorts of effects will influence this probability: factors that move $a_D$ and $a_L$, and factors that shift $F$.

Since our empirical investigation, unlike previous empirical studies, controls for the characteristics of both parties in the suits, it suffices to look at direct effects on the probability of litigation. These effects are (letting $f$ be the probability density function):

$$
\frac{d\lambda}{dP_1} = \frac{\partial}{\partial P_1} [F(a_D; P_1, x_2) - F(a_L; P_1, x_2)],
$$

$$
\frac{d\lambda}{dx_1} = -f(a_L) \frac{\partial a_L}{\partial x_1},
$$

$$
\frac{d\lambda}{dx_2} = f(a_D) \frac{\partial a_D}{\partial x_2} - f(a_L) \frac{\partial a_L}{\partial x_2} + \frac{\partial}{\partial x_2} [F(a_D; P_1, x_2) - F(a_L; P_1, x_2)].
$$

Notice that we have included

These equations provide a framework for thinking about empirical results and the two factors that influence litigation. Generally, $x_1$ and $x_2$ influence $a_L$ and $a_D$ through the effect R&D has on the stakes each firm has at risk in litigation. Consider the effect of the patent holder’s R&D, $d\lambda/dx_1$. If the industry is such that additional R&D investment allows firms to earn large
additional profits (e.g., patent rents), then R&D investment will lead to greater gains from litigation, shifting $\alpha_L$ to the left (firm 1 would rather sue than settle). All else equal, a patent holder who invests more in R&D in such an industry will be more likely to sue. We find evidence that R&D spending by patent holders in the pharmaceutical and chemical industries—where patent rents are high—increases the probability of suit, but not in other industries, where patent appropriability is not so high. When we control for firm profits (actually, firm market value) to control $\alpha_L$, this effect becomes insignificant in all industries, consistent with the theoretical model.

Shifts in the distribution $F$ provide another margin of influence. We assume that the probability distribution is massed to the left, at low values of $\alpha$. This assumption is motivated by the observation that technologies are diverse and that most pairs of randomly chosen firms will have very different technologies, unlikely to infringe each other’s patents. In the empirical paper we construct a measure of technological distance and find support for this assumption.

This means that if, say, $P_1$ shifts the distribution to the right, then this will increase the probability of litigation—more mass will fall between $\alpha_L$ and $\alpha_D$. Since greater patent refinement—more patents, better quality patents, better monitoring, etc.—should shift $F$ to the right, this is exactly the relationship we should expect, and we do, indeed, find that firms with larger portfolios are more likely to sue, all else equal.

Similarly, firm 2’s R&D spending, $x_2$, may also shift the distribution, but this effect could be positive or negative. If firm 2 uses development investment mainly to “invent around” patents or aid piracy, then probability mass is shifted to the left out of the litigation interval—with this sort of infringement avoidance, firm 2 would be less likely to be found to infringe. Alternatively, if increasing firm 2’s development investment exposes it to greater risk of inadvertent infringement, then probability mass is shifted to the right into the litigation interval. When we include firm profits (market value) in the regression to control for $\alpha_L$ and $\alpha_D$, we find a strong positive effect of firm 2’s R&D on the probability of litigation. This suggests that most defendants are inadvertent infringers rather than pirates or firms attempting to cheat by inventing around.

The distribution of trial outcome probabilities is affected not only by the endogenous patenting and development choices of the firms, but also by a variety of exogenous factors of interest to us. This framework can also be used to think about policy changes. For example, relaxed antitrust rules increase the attractiveness of settlement, shifting $\alpha_L$ to the right, while reduced litigation cost and larger rents increase the attractiveness of litigation, moving it left.
Similarly, legal changes that expand the scope of patent rights or make patent boundaries less clear would shift the distribution $F$ to the right.

V. Conclusion: Vague Property Rights, Patent Disputes, and Patent Lawsuits

In an ideal (though not necessarily optimal) patent system in which validity and scope are clear, potential patent lawsuits would result in either a certain win or a certain loss for the patent owner. Then there would not be any patent disputes or lawsuits filed. In innovative firms would seek an ex ante license or avoid adopting patented technology. And patent owning firms would have no incentive to make strategic investments in patent refinement. The distribution of $F$ would be bi-modal, falling entirely within the acquiescence and deterrence regions.

In contrast, in our model the vagueness of patent rights leaves firms unsure about the strength of a potential patent lawsuit. In equilibrium, there are patent disputes, i.e., ex post settlement and litigation, when the realization of $\alpha$ falls into the interval $(\alpha_A, \alpha_D)$, and there are (observable) lawsuits filed when $\alpha$ falls into the interval $(\alpha_F, \alpha_D)$.

Our model provides a framework for analyzing patent law changes affecting the certainty of patent rights. In the early 1980s, all patent appeals were consolidated in the newly created Federal Circuit. One goal of this change was to increase the clarity of patent rights. In the mid 1990s, patent claim construction was moved from juries to judges; again, one goal of this change was to increase the clarity of patent rights.

Clearly, if these reforms succeeded, then we should observe a reduction in lawsuits. More subtly, the model also provides a framework for predicting the effect of these reforms on the profit, development investment, and patenting behavior of innovative firms. We plan to investigate these effects in future work, and we hope to learn whether patent vagueness is a substantial impediment to innovative activities.

REFERENCES


End Notes

*Research on Innovation and Boston University School of Law, and Boston University School of Law, respectively. JEL Codes: K41, O31, O34.

1 We refer the reader to our working paper Bessen and Meurer (2006) for other assumptions about the third stage payoffs.


3 The proofs of this and all other results are contained in the working paper.

4 This inference actually requires a slightly stronger assumption: that the probability density, $f$, monotonically decreases. Given the evidence that the probability mass is concentrated at low values of $\alpha$, this would seem to be a parsimonious assumption for a large sample of diverse firms.

5 In addition, we find that most defendants spend heavily on R&D—they are not simple copyists. Also, a substantial portion of lawsuits occur between firms that are in completely different industries and are technologically distant, again suggesting inadvertent or unavoidable infringement.

6 Ignoring private information and other causes of litigation.
Abstract: This paper provides the first look at patent litigation hazards for public firms during the 80s and 90s. Consistent with our model, litigation is more likely when prospective defendants spend more on R&D, when prospective plaintiffs acquire more patents and when firms are larger and technologically close. Public firms face dramatically increased hazards of litigation as plaintiffs and even more rapidly increasing hazards as defendants, especially for small public firms. Both trends tend to reduce R&D incentives. The increase cannot be explained by patenting rates, R&D, firm value or industry composition. Legal changes are the most likely explanation.
Introduction

The annual number of patent lawsuits filed in the U.S. doubled during the 1990s (see Figure 1).\(^1\) Is this cause for concern?

Other research suggests that patent litigation can affect innovation incentives. Economic historian Zorina Khan (2004) argues that the introduction of the patent examination system during the 19\(^{th}\) century reduced the relative number of patent lawsuits and that this substantially spurred inventive activity. Josh Lerner (1995) finds that the threat of litigation deters biotech firms from innovating in some technology fields. Lanjouw and Lerner (2001) find that the use of preliminary injunctions by large firms discourages R&D by small firms. Does the recent jump in patent litigation reduce the incentives firms have to innovate?

We attempt to answer this question with a model of firm patent disputes that may help us understand what is driving the increase in litigation and what effect this has on firm incentives. At root, most patent disputes arise because patent validity and infringement are uncertain. Although patents are often called “intellectual property,” they differ in this respect from real property where the boundaries of a plot of land and the validity of a title usually can be verified at little cost and with little uncertainty. In contrast, the validity of a patent may be challenged and firms often have difficulty determining whether a technology infringes the boundaries of a patent’s claims. Indeed, even district court judges have difficulty determining the boundaries of patent claims—30-40% of their claim interpretation decisions are reversed on appeal (Moore 2005).

If patents worked like real property rights, they would be largely self-policing and there would be few disputes and little litigation. That is, firms would avoid investing in any technology covered by patent claims (or they would obtain an \textit{ex ante} license from the patent holder) and no patent holder would attempt to assert a patent against any firm whose technology fell outside the scope of the patent. But when patents have uncertain validity and their boundaries are poorly defined, then disputes arise that affect firm R&D incentives. Some firms “stumble” and make unauthorized use of patented technology. This might occur because of inadequate investigation of issued patents, but also because the relevant patent had not yet issued, or the scope of the patent rights was unclear, or because the details of the technology were not fully known when funds were committed to development. Furthermore, some patent holders overreach, asserting patent claims against non-infringing firms. The disputes that arise in these cases yield litigation or licensing under the threat of litigation, and sap rents from innovative firms. The reduction in rents

\(^1\)As discussed below, this figure represents case filings reported by the US Patent and Trademark Office and this series only captures about two thirds of all filings. However, the degree of under-reporting is stable over time, so the nature of the trend in total filings is the same.
relative to a situation with clearly defined and certain property rights can be viewed as the cost of patent disputes. This cost reduces innovators’ incentives to invest in R&D.

All else equal, the annual expected cost of patent disputes to a firm varies proportionally with the firm’s hazard rate of entering disputes. Although we observe only those disputes where a lawsuit is filed, under reasonable conditions, trends in the hazard of filing should reflect trends in the total hazard of disputes. Thus firm litigation hazards provide a baseline indicator of the changing effect of litigation on innovation.

Of course, a rising cost of disputes may be accompanied by offsetting benefits. For example, firm dispute hazards might be driven by the number of inventions that a firm has. Then more inventions might lead to more patents and more disputes, but the greater cost of disputes may be offset by greater returns from the larger pool of inventions. To evaluate the possibility of such offsetting benefits, we want a comprehensive understanding of the factors driving the changes in litigation hazards, including, among other things, the number of patents a firm has and, perhaps, measures that capture the value of its inventions.

What drives changes in firm litigation rates? We conduct an empirical analysis at two levels to explore this question. First, we study the probability that one randomly selected firm files suit against another randomly selected firm in the same industry in a given year. Among the right hand side variables we include the size of each firm’s patent portfolio, employment, R&D spending and market value, and the technological proximity of the two firms. This allows us to test various theoretical explanations of firm litigation. These include the possibility that firm behavior affects litigation risk—for example, acquisition of “defensive” patent portfolios or even the conduct of R&D itself may affect a firm’s exposure to litigation risk.

Second, we perform an aggregate analysis, studying the hazards that a firm will engage in patent litigation as a plaintiff and, separately, as a defendant against all possible other parties. This gives us a more comprehensive estimate of the contribution of different factors to the increase in aggregate litigation.

Our paper differs from previous research in two principal ways, one theoretical, the other empirical. First, our model of litigation addresses the origin of patent disputes, not just dispute settlement. Most of the theoretical literature on litigation takes the existence of a dispute as given and then asks what factors determine whether the disputants will settle or proceed to trial. But the rate of lawsuit filing depends as much on the frequency of disputes as the frequency of bargaining breakdown. Our model

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incorporates both. We assume patent-related investments by one firm and investments related to the
development and adoption of technology by another firm interact to create patent disputes. Attention to
the origins of disputes is important because our data suggest that (after controlling for the number of
inventions) more frequent disputes, not more frequent bargaining failures, are driving the increase in
patent lawsuit filing.

Second, our analysis differs from most previous research in that we use the firm as the unit of
analysis as well as randomly selected pairs of firms. Our aim is to understand how firm choices affect
litigation rates and how firms are affected by litigation hazards, so this is a natural modeling choice. With
the important exception of Rosemarie Ziedonis’s study of semiconductor industry patent litigation (2003),
most studies have either looked at the rate of litigation per patent (Lanjouw and Schankerman 2004,
Allison et al. 2004) or have looked at aggregate litigation rates (Landes and Posner 2003, Merz and Pace
1994). Although these statistics are informative, our model provides a richer, multi-factor picture of firm
litigation behavior that can distinguish between a variety of possible explanations for the increase in
litigation rates.

The next section describes our model of patent disputes, some hypotheses from this model, and
the specification of equations we estimate. The second section describes our data and the third reports our
empirical results. The fourth section discusses the interpretation of these results and the fifth section
concludes.

Model and Specification

Dispute, Filing and Settlement

We model how a dispute might arise between a patent owner and a potential defendant, and
whether the parties will resolve the dispute before filing a lawsuit. Our model contains features of Meurer
(1989) and is similar in spirit to Crampes and Langinier (2002). The latter model shows how disputes
might arise because of costly monitoring for infringement. In equilibrium, Crampes and Langinier show
that firms will sometimes gamble and adopt an infringing technology on the hope that they will not be
detected. Our model accommodates costly monitoring, but we also show how disputes might arise
because the scope and validity of patents is uncertain. The details of the model can be found in our
companion paper, (Meurer and Bessen 2005); here we provide a brief overview and summary of relevant
results.

Our model has three stages and two players, firm 1, who owns patents and is a potential plaintiff,
and firm 2, who invests in technologies that might possibly infringe and who is, therefore, a potential
defendant. The game has symmetric information and we characterize the unique subgame perfect Nash
equilibrium. In the model there is one set of related inventions and each firm has only one product (the “product” might be a patent license), we relax these assumptions in the empirical specification. In stage one, firm 1 chooses an investment, $P_1$, in patent “refinement.” We assume firm 1 has exogenously given inventions, and chooses a level of patent protection that determines the probability (actually a distribution of probabilities) of successfully suing firm 2 for patent infringement. Firm 1 can improve its probability distribution by obtaining multiple patents, delaying the issuance of some of its patents through continuation practice, crafting multiple claims, investing in high quality claims and disclosures, conducting a careful prior art search, and so on. We call these activities “refinement” and assume a constant marginal and average cost of refinement, $\rho$. In stage two, firms 1 and 2 simultaneously choose development investments, $x_1$ and $x_2$. We assume a constant marginal and average cost of development, $\delta$.

In stage three, the firms decide whether to dispute infringement and if so, they then decide whether to enter a license agreement or file a lawsuit.

Between stages two and three, the firms observe the probability $\alpha$ that firm 1 could win an infringement suit against firm 2. At the earlier stages the firms know that $\alpha$ is distributed over $[0, 1]$ according to the distribution function $G(\alpha; P_1, x_2, n)$, where $n$ is the “nearness” between the two firms in product or technology space. For convenience we assume $n, P_1,$ and $x_2$ induce shifts of $G$ that satisfy first order stochastic dominance. It is natural to assume that $P_1$ and $x_2$ influence the distribution $\alpha$. A patent dispute only arises when firm 2 adopts a technology that arguably falls within the scope of at least one of firm 1’s patents. Firm 1 can improve its prospect at trial by investing more in patent refinement which shifts the distribution to the right, and firm 2 can affect its prospect at trial through its development investment. Possibly, firm 2 increases its exposure to a lawsuit by increasing it development investment; alternatively, firm 2 might reduce the probability of a successful suit by designing a technology that a court is likely to find outside the scope of firm 1’s patents. For now, we leave open the possibility that $x_2$ shifts the distribution either right or left. Finally, we assume that as the two firms move nearer to each other, so that $n$ grows, the distribution shifts to the right.

The third stage of the model is a hybrid of a strategic and cooperative bargaining. Figure 2 shows the equilibrium outcomes for different values of $\alpha$. We will say there is a patent dispute when both firms have a credible threat of litigation. This occurs when $\alpha_s \leq \alpha \leq \alpha_D$. Filing occurs in a subset of these cases when $\alpha_F \leq \alpha \leq \alpha_D$. Ex ante, the probability of filing which we denote $y = G(\alpha_D) - G(\alpha_F)$.

Figure 2 also shows profit for firms 1 and 2 as a function of $\alpha$. Naturally, firm 1’s profit increases in $\alpha$ and firm 2’s profit decreases. Outside the dispute region, the firms’ profits are invariant to $\alpha$ because

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3 What we observe below in the empirical analysis is, of course, the ex post probability of filing conditional on deterrence not occurring. Assuming rational expectations, so that $G$ is also the ex post distribution, this probability is $(G(\alpha_D) - G(\alpha_F))/G(\alpha_D)$. 

4
the threat of filing is not credible. Within the settlement region, the firms do not file, but the expected profits from filing determine the threat points of the bargaining problem. A higher probability of success for firm 1 from filing translates into higher expected profit from filing, and a stronger bargaining position given settlement.

Figure 2 helps us think about the origins of patent disputes and possible explanations for an increase in the filing of lawsuits. The set of disputes depends on whether the parties have credible threats to sue. Factors that shift $\alpha_A$ to the left and $\alpha_D$ to the right increase the set of disputes. For example, higher stakes and lower litigation costs make it easier for both parties to satisfy the credibility constraint. In addition, a larger patent premium makes it easier for firm 1 to satisfy its credibility constraint. The boundary between settlement and filing depends on the joint profit from those two choices. Relaxed antitrust rules and other changes that reduce settlement cost increase the attractiveness of settlement, while reduced litigation cost and a larger patent premium increase the attractiveness of filing. Besides factors that shift these boundaries we also need to think about the distribution of $\alpha$.

The distribution of trial outcome probabilities is affected by the endogenous patenting and development choices of the firms, and also by a variety of exogenous factors of interest to us. For example, patent refinement investment shifts the distribution of $\alpha$ to the right as the patentee takes care to strengthen its case for validity and the scope of its patent rights. Similarly, legal changes that expand the scope of patent rights or reduce the stringency of patent standards would shift the distribution to the right. Whether the probability of disputes (filing) increases, of course, depends on whether the change shifts more of the mass of the distribution into the dispute (filing) interval.

Hypotheses

Our theoretical model concerns firms developing individual products, and is best interpreted as a model of business units. However, our data are at the firm level. We assume that firm variables are correlated with business unit variables, e.g., larger firms have larger product markets. We also assume that in cross-section, the (ex post) distribution of $\alpha$’s is heavily weighted toward 0 and the probability density decreases monotonically with $\alpha$. In other words, most randomly selected pairs of firms do not have active disputes. Given these assumptions, we are able to frame the following hypotheses:

\[ H1: \text{The probability of litigation between two firms increases with their proximity in technological space, all else equal.} \]

The intuition here is simply that firms pursuing very similar technologies are likely to have greater risk of infringing each other’s patents and thus are more likely to fall into the litigation region.

\[ H2: \text{The probability of litigation between two firms increases with the size of the stakes, all else equal.} \]
Research finds that patents that receive more citations and more likely to be litigated (Lanjouw and Schankerman (2004) and Allison et al. (2004)). Our model predicts this relationship if we assume that highly cited patents are associated with more valuable innovations which increase the stakes for both firms from litigation. Greater stakes relaxes the credibility constraints, and makes filing more attractive relative to settlement. Thus, the size of the filing region grows. We investigate whether other measures of the private value of the innovation are also correlated with filing.

In addition, we investigate factors that are likely to affect the size of the stakes for one firm but not the other. For example, the size of firm $i$ is likely to affect the stakes for firm $i$ but perhaps not firm $j$. The model does not generate a clean prediction about the effect of firm-specific changes in the size of the stakes. The values of $\alpha_A$ and $\alpha_D$ change in a predictable fashion, with $\alpha_A$ moving to the left and $\alpha_D$ moving to the right, but the change in $\alpha_F$ is ambiguous. We will explain below that we do find evidence of firm-specific stake effects, and these effects have interesting implications for interpreting some of our other findings.

**H3a.** The probability that firm 1 sues firm 2 increases with the patent portfolio size of firm 1, all else equal.

This captures the notion that greater effort at patent refinement in the form of a higher patent propensity (after controlling for scale and R&D) increases expected $\alpha$, corresponding to a greater likelihood of falling in the litigation region. Note that in general this increase need not be proportional, that is, the elasticity of the probability of filing with respect to firm 1’s patent portfolio size may be less than one. A larger portfolio size implies a larger probability that firm 1 will win a suit against firm 2, $\alpha$, and this increases the likelihood of litigation. But $\alpha$ may exhibit diminishing returns with portfolio size, e.g., if each patent has an independent probability of being found infringed.

**H3b.** If firms use patent portfolio trading to avoid litigation, then the probability that firm 1 sues firm 2 will decrease with firm 2’s patent portfolio size, all else equal.

That is, firm 2’s “defensive” portfolio will reduce the probability of filing and increase the probability of settlement.

The next hypotheses concern the relationship between development investment and the probability of filing. The nature of the relationship depends on the sensitivity of the stakes in patent litigation to the development investments of the two firms. It also depends on how development investment by firm 2 influences the distribution of $\alpha$.

**H4a.** If development investment by firm 1 has a stronger positive effect on firm 1’s filing payoff than on the joint settlement payoff, then the probability of litigation should increase with firm 1’s development investment, all else equal.
Referring to Figure 2, the critical question is whether an increase of $x_1$ causes $\alpha_F$ to move to the left. Such an effect is most likely to appear in the pharmaceutical and similar industries, where the share of innovation rents attributable to patents is large, output share of R&D is high, technologies are discrete, and products are few. On the other hand, in the electronics or computer industries, development investment by firm 1 might have little effect on the litigation stakes or the value of $\alpha_F$.

**H4b. If the development investment by firm 2 has a weak effect on the stakes in patent litigation and firm 2 uses development investment mainly to “invent around” patents, then the probability of litigation should decrease with firm 2’s R&D, all else equal.**

The intuition here is that those prospective defendants who invest more in inventing around will be less likely to be found to infringe firm 1’s patents. Those firms that simply imitate without expending resources to invent around will be more likely to be sued. In terms of Figure 2, the assumption that the stakes are not very sensitive to $x_2$ means that $\alpha_F$ and $\alpha_D$ do not move very much. The assumption that inventing around is important means that an increase in $x_2$ shifts the distribution of $\alpha$ to the left.\(^4\)

**H4c. If development investment by firm 2 has a stronger positive effect on firm 2’s filing payoff than on the joint settlement payoff and if development investment by firm 2 has little effect on the distribution of $\alpha$, then the probability of litigation should increase with firm 2’s development investment, all else equal.**

If development investment by firm 2 has little effect on the distribution of $\alpha$, then any change in the probability of filing is driven by changes in the filing interval [$\alpha_F$, $\alpha_D$]. An investment that significantly increases firm 2’s stake in litigation makes settlement less appealing and makes it easier for firm 2 to satisfy the credibility constraint, thus the probability of filing increases.

**H4d. If development investment by firm 2 has a weak effect on the stakes in patent litigation and if development investment by firm 2 shifts the distribution of $\alpha$ to the right, then the probability of litigation should increase with firm 2’s development investment, all else equal.**

This captures the notion that prospective defendants who invest more in development (deliberately or inadvertently) expose themselves to greater risk of infringement. Inadvertent infringement may be common because of the difficulty determining whether a technology is likely to infringe a patent, and because relevant patents may issue after development and even adoption is completed. Uncertain detection and trial outcome also contribute to the positive relationship between development investment and infringement exposure.

These hypotheses encompass several variations of the model that may be helpful to understand what drives patent litigation and what may explain the trends in litigation.

\(^4\) Recall we also assume that $g(\alpha)$ is decreasing in $\alpha$ so that the loss in probability density at the $\alpha_F$ boundary is greater than the gain in density at the $\alpha_D$ boundary.
Specification

These hypotheses can be nested in a simple regression. We define a general logit regression equation:

\[ y_{ABt} \equiv P[\text{firm } A \text{ sues firm } B \text{ in year } t] = \frac{e^{z+\delta_t}}{1 + e^{z+\delta_t}} \]

\[ z \equiv \alpha X_{At} + \beta X_{Bt} + \gamma X'_{At} X_{Bt} + \varepsilon \]

where \( X_{it} \) is a vector of firm characteristics for firm \( i \) at time \( t \) and \( \delta_t \) is a time dummy. Following the above discussion, this vector might include the R&D spending, scale (employment), and patent portfolio sizes of both firms and the technological distance between them. This equation is estimated over pairs of firms who are potential litigants.

Because the potential number of pairs of firms is very large and because we want to understand the aggregate effect of litigation on firms, it is also helpful to calculate firm hazards. As long as the probability that firm A sues firm B is independent of the probability that firm A sues firm C, etc., the expected number of suits can be calculated as sums of these probabilities:

\[ h^A_{it} \equiv E[\text{number of suits filed by A in year } t] = \sum_{j \neq A} y_{AJt} \]

\[ h^B_{jt} \equiv E[\text{number of suits filed against B in year } t] = \sum_{j \neq B} y_{jBt} \]

Note further that if \( z \) and \( y \) are sufficiently small, \( y_{ABt} \approx e^{\delta_t} (1 + z) \). Using this approximation,

\[ \ln h^A_{it} \approx \phi X_{At} + \mu_t + \varepsilon \]

\[ \phi = \alpha + \gamma \bar{X} \]

\[ \mu_t = \delta_t + \ln(N-1) + \beta \bar{X}_t + \gamma (\bar{X}_t - \bar{X}) \]

where \( \bar{X}_t \) is the mean over firms and \( \bar{X} \) is the mean over firms and years. Note that this form is the familiar log linear Poisson regression. A similar expression can be derived for the defendant’s hazard,

\[ \ln h^B_{jt} \approx \psi X_{Bt} + \eta_t + \varepsilon \]

Finally, note that if there are no interaction terms in (4), that is, if \( \gamma = 0 \), then \( \phi = \alpha \) and \( \psi = \beta \). In words, the coefficients of the Poisson regressions, (5) and (6), should match those of the corresponding variables in the logit pairs regression, (4).
Data Description

Data Sources

Our research matches records from three data sources: lawsuit filings from Derwent’s Litalert database, firm financial data from Compustat, and patent data from the USPTO made available by the NBER.

As in most of the prior research, we use lawsuit filings as our measure of litigation. Patent disputes are properly viewed as a process consisting of many stages where settlement is possible at each stage and costs are incurred during each stage. Although a trial is the costliest stage, the majority of legal costs occur prior to trial (AIPLA, 2003) and opportunity costs experienced by the firm (e.g., postponed business) may also be quite large. Talks with patent lawyers suggest that perhaps half of all patent disputes are resolved prior to filing a lawsuit. Thus the event of a filing represents a foregone opportunity to settle and a credible commitment to incur some level of litigation cost that could have been avoided.

Our primary source of information on lawsuit filings is Derwent’s Litalert database, a database that has been used by several previous researchers (Lanjouw and Schankerman, 2004, Ziedonis, 2003). Federal courts are required to report all lawsuits filed that involve patents to the U.S. Patent and Trademark Office (USPTO) and Derwent’s data is based on these filings. Beginning with the Derwent data from 1984 through 2000, we removed duplicate records involving the same lawsuit as identified by Derwent’s cross-reference fields. We also removed lawsuits filed on the same day, with the same docket number and involving the same primary patent. Sometimes firms respond to lawsuits by filing counter-suits of their own, perhaps involving other patents. Since our main focus is on disputes rather than on lawsuit filings per se, we also removed filings made within 90 days of a given suit that involved the same parties. Finally, we removed filings where the current PTO Commissioner was a party. This left us with 16,534 lawsuits filed from 1984 through 2000 (see Figure 1). Almost all of these lawsuits involved utility patents, including re-issued patents.5

Previous researchers have found that apparently not all lawsuits involving patents do, in fact, get reported to the USPTO. The Federal Judicial Center (FJC) collects data directly from the administrative office of the courts and they consistently report a larger number of filings. Two potential problems arise from under-reporting: a possible change in the reporting ratio over time, leading to spurious trends in the Derwent data, and possible selection bias. After de-duplicating Federal Judicial Center data, we found that our database had only 64% of the number of lawsuits contained in the FJC data. However, although there was some year-to-year variation in this ratio, it appeared to be stable over time: the ratio averaged

5 In a small percentage of cases Derwent did not report a patent or listed a design patent.
63.9% from 1984-90 and 64.1% from 1991-99. There thus appears to be no significant trend in this reporting ratio. Also, using an extensive match between the two files, Lanjouw and Schankerman (2004) find no difference between reported and unreported cases over a range of variables, providing no suggestion of selection bias. Since the FJC data do not report all parties to a lawsuit, we chose to use the Derwent data despite this under-reporting. In the tables below, when we report firm litigation hazards, these estimates have been corrected for under-reporting (they have been divided by .64).

To explore characteristics of firms involved in these lawsuits, we matched the listed plaintiffs and defendants to the Compustat database of U.S. firms from 1984-99 that report financials (excluding American Depository Receipts of foreign firms traded on US exchanges). These data were based on merged historical data tapes from Compustat and involved an extensive process of tracking firms through various types of re-organization and eliminating duplicate records for firms (e.g., consolidated subsidiaries listed separately from their parent companies).

The lawsuit data were matched to the Compustat data by comparing the litigant name with all domestic firm names in Compustat and also a list of subsidiary names used in Bessen and Hunt (2004).

At least one party was identified as a publicly traded US firm in 42% of the 16,534 cases.

To check the validity and coverage of this match, we randomly selected a number of parties to suits and then checked them manually using various databases including PACER, LexisNexis, the Directory of Corporate Affiliations and the LexisNexis M&A databases. Although we were not able to definitively identify all parties, the rate of false positives was not more than 3% (no more than 5 of 165 parties were found to have been falsely matched) and the rate of false negatives was no more than 7% (no more than 34 of 502 public companies were not matched).

To obtain information about each firm’s non-litigated patents, we also matched Compustat firms to the NBER patent database (Hall et al., 2001). To match the USPTO assignee name to the Compustat firm name, we began with the match file provided by the NBER. To this we added matches on subsidiaries developed by Bessen and Hunt (2004), we manually matched names for large patenters and

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6 Lanjouw and Schankerman (2004) report that their comparable ratio was stable during the 90s. At the suggestion of Zorina Khan, we also compared our data to counts of lawsuit activity from LexisNexis, even though these data are not directly comparable. The ratio of LexisNexis counts to FJC data, however, did exhibit marked variation over time.

7 This work was conducted by Bob Hunt and Annette Fratantaro at the Federal Reserve Bank of Philadelphia for an earlier project and we thank them for graciously sharing it with us.

8 A software program identified and scored likely name matches, taking into account spelling errors, abbreviations, and common alternatives for legal forms of organization. These were then manually reviewed and accepted or rejected. Note that this match is based on the actual parties to litigation, not the original assignee of the patent at issue.
R&D-performers, and we matched a large number of additional firms using a name-matching program. In addition, using data on mergers and acquisitions from SDC, we tracked patent assignees to their acquiring firms. Since a public firm may be acquired, yet still receive patents as a subsidiary of its acquirer, we matched patents assigned to an acquired entity in a given year to the firm that owned that entity in that year. This matched group of firms includes 10,736 patent assignees matched to one of 8,444 owning firms in Compustat, with as many as five different owners matched to each assignee. This matched group accounts for 96% of the R&D performed by all US Compustat firms, 77% of all R&D-reporting firms listed in Compustat and 62% of all patents issued to domestic non-governmental organizations during the sample period. Sample statistics show that this matched sample is broadly representative of the entire Compustat sample, although it is slightly weighted toward larger and incumbent firms. Testing our match against a sample of 131 semiconductor industry firms that had been manually matched, we correctly matched 90% of the firms that accounted for 99.5% of the patents acquired by this group.

Variables

The main variables of interest are as follows:

*The number of suits per firm per year.* This is the number of suits to which the firm is a party. We also sought to determine whether the firm was attempting to enforce a patent or whether the firm was seeking to defend against a patent. The Derwent data does not distinguish whether the suit filed is an infringement suit or a declaratory judgment suit. As a prerequisite to filing a declaratory action, a firm must show it has been threatened with an infringement suit; the declaratory action aims for a judgment that the patent is uninfringed or invalid. To classify each suit, we first identified whether the patent assignee at issue matched one of the parties to the suit. If the assignee matched a plaintiff, the suit was classified as an infringement suit; if the assignee matched a defendant, the suit was classified as a declaratory action. We were able to match the assignee for 83% of the suits, and of these, only 17% were declaratory actions. If the assignee did not match a party to the suit, then it was classified as an

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9 A similar software program determined matches between the two files by identifying firm names that matched after taking into account spelling errors abbreviations and common alternatives for legal forms of organization. In addition, a separate program identified Compustat firms with unique names that were not found in the USPTO assignee file. These were classified as firms that did not obtain patents through 1999.

10 This dynamic matching process is different from that used in the original NBER data set which statically matched a patent assignee to a Compustat firm. These data were developed with the help of Megan MacGarvie, to whom we are indebted.

11 Thanks to Rosemarie Ziedonis, who originally compiled this data, for sharing it with us.

12 These numbers are quite similar to findings by Moore (2002) and Lanjouw and Schankerman (2004).
infringement suit because there are relatively few declaratory actions. This classification then allowed us to create two new variables, the number of suits per year for which the firm was a “patentee litigant” (that is, plaintiff in an infringement suit or defendant in a declaratory action) and the number of suits per year for which the firm was an “alleged infringer” (the reverse). Below when we speak of one firm “suing” another, we mean that firm is a patentee litigant and the other firm is an alleged infringer, even though the suing firm may not actually be the plaintiff.

*Portfolio size.* To obtain a measure of firm patent portfolio size, we used the number of patents assigned to the firm over the previous eight years. We chose eight years because this number allowed us to capture a reasonable measure of the patents effectively in force without consuming too much of our sample. This is our main proxy for patent refinement effort.

*Patent characteristics.* We also estimated the “adjusted” number of claims per patent, citations made per patent (backward citations), and citations received per patent (forward citations) for the litigated patents and also for the firm’s entire patent portfolio. Since these characteristics tend to change across patent classes, the “adjusted” characteristics are estimated as deviations from the mean of the patent’s class.

*Newly public firm.* This dummy variable is set to one only during the first five years in which the firm appears in Compustat. This group largely consists of firms which have recently gone public, and these are largely young firms.

*Industry groups.* We divide firms into eight industry groups according to their primary product category as identified by Compustat: SIC 28 (chemicals, including pharmaceuticals), SIC 35 (machinery, including computers), SIC 36 (electronics), SIC 38 (instruments), other manufacturing (SIC 20-39, excluding the above), SIC 73 (business services including software), SIC 50-59 (retail and wholesale), and other non-manufacturing. These classifications use the SIC code assigned by Compustat for the primary line of business of the firm for the given year.

*Technological closeness.* Two firms may use similar technologies or very different technologies. To measure their technological “closeness,” we calculate a measure developed by Jaffe (1986). This measure is computed by first calculating the share of each firm’s patents the USPTO assigns to each technology class as the patent’s primary classification. For each firm we get a vector of 426 class shares. The technological closeness of two firms is calculated as the uncentered correlation of the two corresponding vectors. We do this calculation for all public firms with patents over two time periods:

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13 We ran our analysis after excluding cases without a matched assignee and the results were broadly similar.

14 There are some observable differences between, say, plaintiffs in infringement cases and defendants in declaratory actions (the latter tend to be somewhat larger firms). However, we ran our analysis separately for these different groups and the results were broadly similar. For this reason, we only report the combined results here.
1984-91 and 1992-99. Also, for each firm we compute weighted sums of other firms’ patent portfolio sizes and other firms’ R&D expenditures using the closeness measure as a weight. These measures represent the number of patents and R&D spending in the firm’s “neighborhood.”

Firm financial and other data. These include: employees in thousands; R&D, cashflow and sales all deflated by the GDP deflator; capital defined as property, plant and equipment deflated by the NIPA capital goods deflator; and firm market value (long term debt plus the market value of common and preferred stock).

Characteristics of the samples

We use two main samples in our analysis. The first is the matched sample described above with 118,495 firm-year observations from 1984-99. The second sample is generated from the first. It consists of observations of pairs of firms for each year and we use this to explore the probability that one firm will sue another. All pairs of firms that share the same primary line of business (at the 4-digit SIC level) are included twice (A sues B and B sues A), comprising 1,240,580 observations from 1984-99 after excluding cases with missing variables and firms in retail and wholesale industries.

Table 1 shows means and medians of several variables estimated for firm-years from the basic Compustat sample. The first column shows all firm-years and the second shows just those observations with positive patent portfolio size. The third column then shows observations where the firm was involved in one or more patent suits.

Firms who patent tend to be larger and less likely to be newly public than all firms. Firms involved in litigation tend to be much larger than these, although they are no less likely to be new firms. Patent litigation is very much dominated by large, R&D-intensive firms in absolute terms. Below we look at relative hazards by size.

The last two columns compare patentee litigants with alleged infringers. If patent infringement were largely a matter of low-tech copyists imitating patented products or processes, then we should see a much lower level of R&D spending among alleged infringers and much higher percentages of firms reporting no R&D and having no patent portfolios. This is hardly the case. Alleged infringers spend about the same on R&D as their accusers (more in the mean, slightly less in the median). Alleged infringers do have a somewhat greater propensity to be firms who do not report R&D or who do not obtain patents

15 The last column excludes firms in the retail and wholesale industries. Firms in these industries are often named in suits because they distribute allegedly infringing goods, but only rarely for making or using such goods themselves. We exclude them here to provide a clearer picture of the extent to which alleged infringers are low tech copyists. Including these firms does not change the estimates substantially.
(bear in mind, many defendants are retailers). It is possible, of course, that relatively more low-tech copyists are found among unlisted firms.

Patent litigants, both patentees and alleged infringers, tend to have relatively large patent portfolios on average. We also report mean “adjusted” characteristics of these portfolios. We adjust for differences over patent technology classes by reporting the means as deviations from the mean of the respective patent classes. Thus public firms in general have more highly refined patents that contain more claims and make more citations than all patents in matching patent classes, presumably reflecting greater effort put into patent prosecution. Public firms also receive more subsequent patent citations.

But note that patentee litigants appear to put greater effort into patent refinement (they make more citations) than do other public firms. Alleged infringers obtain patents with fewer claims and backward citations. This suggests a degree of endogeneity: firms anticipate that they may assert their patents and so they put extra resources into refining them so that they will more likely be held valid and infringed (they will draw a higher $\alpha$).

Finally, note that patentee litigants have patent portfolios that receive more subsequent citations. That is, all the patents owned by firms that sue are cited more often and not just their litigated patents, perhaps suggesting that forward patent citations are in part a response to litigious behavior. This plus the evidence above suggests that the observed correlation other researchers have found between litigation and patent characteristics (Lanjouw and Schankerman 1999, Allison et al. 2004) may involve causality that runs in both directions.

**Empirical Results**

**Basic measures of litigation hazard**

Table 2 shows mean measures of litigation hazard for public firms with positive patent portfolios and positive R&D spending. The first two columns show statistics for the hazard of the firm enforcing its patents as a patentee litigant and the first three rows show the overall hazards and for 1987 and 1999. The first column shows the expected number of such suits per year. The hazard grew substantially from 1987 to 1999.

The second column imputes a litigation rate per patent. This is calculated as the mean annual number of suits in which firms are patentee litigants divided by the mean number of patents granted to firms per year. This estimate represents the mean number of suits per patent over the observed time
In contrast to previous research, however, this estimate reflects the effective patent term. We estimate a hazard of 1.18% of lawsuits per patent. By comparison, Lanjouw and Schankerman (2004) report a rate of 1.04% lawsuits per patent for a sample of public firms. We might expect our figure to be somewhat higher because our estimate takes into account effective patent term and our sample of public firms includes many more small firms, who tend to have higher rates of litigation per patent. Still, the correspondence is close.

As Lanjouw and Schankerman point out, the hazard of litigation per patent did not change much during the 90s. We show a small increase (11% over the interval from 1987 to 1999). In effect, the increase in firm patenting rates largely offset the increase in the rate of litigation per firm.

The measures for litigation hazards where the firm is the alleged infringer are shown in columns three and four. The rate of litigation per R&D dollar is calculated as the sample mean rate of litigation per firm divided by the sample mean deflated R&D expenditure. In general, the hazard of a public firm being an alleged infringer has been slightly less than the hazard of the firm being a patentee litigant. But the hazard of being an alleged infringer increased sharply, more than doubling from 1987 to 1999. Moreover, measured relative to R&D spending, the rate still increased sharply—the hazard of being sued for each dollar of R&D increased by 70% from 1987 to 1999.

The next three rows show these measures for firms of different sizes and for newly public firms. Lanjouw and Schankerman report that small firms have a much higher rate of litigation per patent, and we find the same. A firm with fewer than 500 employees faces an enforcement hazard per patent that is about four times larger than the hazard faced by a larger firm. In addition, we find that the hazard of being sued relative to R&D spending is nearly six times larger for a small firm. Newly public firms show a similarly pattern of increased relative hazards.

These large differences emphasize that multiple factors influence these hazards. A simple model where, say, the hazard of being a plaintiff is proportional to a firm’s patent portfolio size is likely to fit the

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16 Suppose the effective patent term is $T$, the grant rate is $n$, and the litigation rate is $l$. Then the firm’s effective patent portfolio at any time is $nT$, so the annual number of suits per patent is $l/nT$ and over the entire effective patent term the expected number of suits per patent is just $l/n$. Since the means are estimated over a limited time period, these estimates effectively assume that the litigation rate per patent is the same before, during and after the sample period. Since the patent term is factored out, this estimate is robust to variation in $T$ by construction.

17 The effective patent term may be shorter than the statutory term of 20 years from the grant date because of failure to pay maintenance fees, because the technology becomes obsolete, or because of financial distress to the assignee. Patent terms can also be extended because of regulatory delay; this is common for pharmaceutical patents.

18 If the rate of litigation per $billion of R&D is instead calculated as the mean individual ratio of the number of suits to R&D expenditures and this figure is trimmed of the upper 1% tail, the mean rate is 3.7 for the entire period, 1.3 for 1987 and 3.8 for 1999. This represents a 193% increase from 1987 to 1999. The weighted mean (weighted by R&D) increased 73% from 1987 to 1999 (from 1.1 to 1.9).
data poorly. Instead, we need to use a multiple regression approach to understand the factors giving rise to trends in the hazards.

Finally, the bottom of Table 2 shows these statistics reported for different industry groups. Different industries seem to exhibit very different patterns. The instruments industry has high hazards relative both to its patents and its R&D, while business services have low litigation rates by both measures. Chemicals including pharmaceuticals has a high rate of litigation per patent, but a low rate per R&D. Electronics has the reverse: a low rate per patent and a high rate per R&D dollar (see similar numbers from Ziedonis, 2003 for semiconductors).

Again, mono-causal explanations are unlikely to explain these diverse patterns. For example, the semiconductor industry is sometimes described as having a low rate of litigation per patent because the complex technology gives rise to patent trading based on “mutually assured destruction” (Allison et al. 2004). But this explanation by itself seems unable to account for the above average rate of litigation relative to R&D spending in semiconductors.

What difference do industry and technological closeness make?

We next look at characteristics of the pairs of firms involved in lawsuits. Do firms tend to sue firms within their own industry or those in other industries? Do they tend to sue firms that patent similar technologies or those that patent more remote technologies? Table 3 provides some simple analysis for suits where both plaintiffs and defendants are public firms.

Fully 29% of these suits occurred between firms whose primary line of business is in the same four-digit SIC industry. But 28% involved firms that did not have a business segment in common even at the three-digit SIC level. Compustat reports major business segments by industry of firms since 1985. The second column of the table includes pairs of firms who share businesses in the same three-digit classification but whose primary businesses are in different industries. This is a very broad classification and likely includes many pairs that are not direct competitors (e.g., computer manufacturers and stapler manufacturers are in the same three-digit SIC classification). Nevertheless, a substantial number of suits appear to involve firms that are not market competitors.19

Perhaps many of these suits are between firms that use similar technologies. We use the technology closeness measure described above to consider this possibility. Firms within the same industry tend to have high closeness measures, but the closeness measure also varies independently of industry, e.g., Apple Computers and Intel do not compete directly in their major markets, but they have a closeness

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19 Some of these suits are probably against distributors of infringing products. The table excludes firms in the retail and wholesale industries for this reason. However, manual inspection of some of the reported suits revealed that many are not against distributors.
of 0.53. The first row shows the percentage of pairs with closeness of less than 0.5 and the second row those pairs with closeness greater than or equal to 0.5. Still, 24% of the pairs neither share an industry segment nor are technologically close.

Thus although many suits, probably the majority, occur between firms that are close either in the market place or in their patent portfolios, a substantial percentage also occurs between firms that are distant. This suggests that it might be prohibitively expensive for firms to clear their innovations for possible infringement accurately. There may simply be too many patent holders that pose a litigation threat but who have dissimilar technologies and products. If so, then inadvertent infringement will not occur infrequently.

**Regression analysis of pairs**

To analyze the trends in litigation hazards, we begin by estimating logit regressions of the probability that a firm with given characteristics will sue a firm with other characteristics in a given year. For tractability, we estimate this probability out of a sample of all pairs of firms who share the same primary industry. We also exclude firms that are not matched to the patent database and firms in the retail and wholesale industries (where litigation is likely to be quite different and there were no intra-industry suits in these industries). Excluding observations missing key data, there were 1,240,580 such pair-year observations from 1984-99.

Table 4, column one shows the simplest estimates. Firm employment size is clearly significant for both parties with a coefficient of .54 for the patentee litigant and .39 for the alleged infringer. Both coefficients are significantly greater than zero, suggesting that scale matters both for plaintiffs and defendants because it is associated with larger stakes in litigation. But both coefficients are also significantly less than one. This may be because larger companies may also be more diversified, so that the stakes for the particular business unit at risk do not grow as fast as the overall firm size. If we imagine that employment simultaneously grows for both the firms, then we see that the probability of litigation grows by almost the same proportion (because .54 + .39 = .93). Thus, we see evidence that a general increase in stakes is associated with an increasing in filing (Hypothesis 2).

All the other continuous variables are scaled by firm employment. The coefficient on the log of the patentee litigant’s patent portfolio per employee is also positive and highly significant, consistent with Hypothesis 3a. More patents mean that the patentee has better chances of winning in court against the prospective infringer. This coefficient is also significantly less than one.

The coefficient on the log of the alleged infringer’s patents per employee is negative, but not significantly different from zero, providing weak support for Hypothesis 3b.
Regarding the two parties’ R&D spending per employee, the coefficient for the patentee litigant is not significantly different from zero. This result holds for all of the variations shown in Table 4. On the other hand, the coefficient for the alleged infringer’s R&D is positive and significant. This pattern is consistent with Hypotheses 4c and 4d — higher R&D either increases litigation stakes, or increases a firm’s exposure to being sued for patent infringement. These results are also inconsistent with the Hypothesis 4b, suggesting that defendants in patent lawsuits are not merely copying to avoid spending R&D or only spending as necessary to “invent around” patents.

Our results relating to number of employees help us interpret our results relating to R&D spending per employee. We find a positive relationship between number of employees of the patentee litigant and number of employees of the alleged infringer, and the probability of suit. Our model leads us to believe that these effects arise because firm size affects firm stakes; it does not seem plausible that firm size affects the distribution of $\alpha$. The employee size data suggest that an increase in the patentee litigant firm-specific stakes has a greater impact on filing than an increase in the alleged infringer firm-specific stakes. Our results on R&D spending per employee by the patentee litigant suggest that R&D spending does not have the statistically significant effect on filing (via stakes) displayed by patentee litigant employee size. Thus, we doubt that R&D spending per employee by the alleged infringer has a significant effect on filing (via stakes). But we do observe a statistically significant effect of alleged infringer R&D intensity on filing. We interpret this effect as arising from an exposure effect; greater R&D intensity exposes a firm to a greater risk of suit, and in terms of the model, shift the distribution of $\alpha$ to the right. In other words, we favor Hypothesis 4d over 4c.

Column 2 adds our measure of technological proximity. The coefficient is economically large and statistically highly significant, supporting Hypothesis 1. This is a strong effect, especially since the sample only includes pairs that are already in the same primary SIC industry. The addition of this variable reduces the scale coefficients a bit, perhaps suggesting that firms of larger size within an industry may also inevitably have more overlapping technology.

Also, the coefficient on the alleged infringer’s patent portfolio size becomes more negative and statistically significant. This suggests a possible interaction between “defensive” patenting and technological proximity. This idea is explored further in Column 3 where both patent portfolio size variables are interacted with a categorical variable indicating whether the firms have a technological closeness greater than or less than 0.5 (about 8% of the samples has technological closeness greater than 0.5). Both of the close coefficients have larger magnitudes in absolute value than their distant counterparts. This suggests that defensive patenting mainly affects litigation among firms that have chosen to be close to rivals in technology space.
The fourth column repeats the regression of the first column, but adds a term capturing the interaction of the two parties’ log patent portfolio sizes. The coefficient of this term is not statistically significant. We also tested a variety of other interactions to see if there were possible size interaction effects or asymmetric patent portfolio effects (e.g., large portfolio suing small portfolio). None of these were significantly different from zero.

The fifth column repeats the regression of the first column, adding variables for log market value per employee and log capital per employee. The market value variable may capture aspects of the firms’ stakes at risk in litigation that are not captured by other variables. The positive coefficients suggest this may be so. The measure of capital intensity may indicate the extent to which the firm is at risk of holdup. Alleged infringers with large capital costs may be particularly vulnerable to patent injunctions, so they may settle more readily, avoiding litigation. The coefficient on the alleged infringer’s capital intensity is negative and significant at the 5% level, providing some support for this hypothesis. The coefficient on the patentee litigant’s capital intensity is also negative (but only significant at the 10% level), perhaps suggesting that capital intensive patent holders also settle more frequently to avoid holdup associated with counter-suits.

Regression analysis of aggregate hazards

As described above, the firm hazard of being a patentee litigant equals the sum of the probabilities of litigation for all possible firms the patentee might sue, assuming these probabilities are independent. The hazard of being an alleged infringer is likewise a sum over possible plaintiffs. This means that the coefficients of firm hazards may have a simple relationship to the coefficients estimated in Table 4. In particular, if the coefficients on interaction terms involving a variable are zero, then the coefficients on that variable should match. On the other hand, we estimate the hazards over a different sample than the sample used in Table 4—the new sample includes suits where the opposing party may be in a different industry and may not be a public firm.

Table 5 reports estimates of firm hazard Poisson regressions for all public firms from 1984 to 1999. The dependent variable in the upper panel is the number of times that the firm is a patentee litigant in a year; in the lower panel, the dependent variable is the number of times that the firm is an alleged infringer in a year. As before, the continuous variables are scaled by firm employment.

Despite the difference in samples, the coefficients in column 1 are close to those in column 1 of Table 4: the coefficient on the patentee litigant’s log portfolio size per employee is .39 in both tables, the coefficient on log employment is .47 compared to .54 in Table 4; the coefficient on the alleged infringer’s log deflated R&D per employee is .26 compared to .25 in Table 4, and that on log employment is .48 compared to .39. The only substantial difference is in the coefficients on the alleged infringer’s log patent
portfolio per employee which is now .10, but was -.08 in Table 4. Since we suggested above that this coefficient may be influenced by technological closeness, and since the current sample includes many more firms that are more distant (since they are no longer constrained to be in the same industry), this may reflect less defensive patenting among firms that are not technologically close.

We tested this and all the other regressions in this table for over-dispersion, which we found to be significant. For this reason, we use standard errors that are robust to heteroscedasticity. Also, we ran negative binomial regressions (not shown). The coefficients on these were quite similar to those from the Poisson regressions.

Column 2 adds the patentee litigant’s log R&D to employment (and a dummy variable for zero reported R&D) and log capital per employee in both regressions. Column 3 further adds log market value per employee, the log of other firms’ closeness-weighted patent portfolios and the log of other firms’ closeness-weighted R&D. As discussed above, the coefficients on capital intensity may reflect evidence of strategic patenting and they are both negative and significant. The distance weighted measures do not appear to have significant effects, perhaps because other variables already capture the effect of close competitors.

Table 5 also shows the coefficients on industry dummies (“Other non-manufacturing” is the excluded category). The pattern is quite similar to the pattern observed in Table 2. Firms in chemical, pharmaceutical and instruments industries are more likely to sue; firms in non-manufacturing industries are much less likely to sue. Firms in electronics and instruments and retail/wholesale industries are more likely to be sued. Firms in business services including software and other non-manufacturing are less likely to be sued.

Table 5 does not display the year dummies, but the year dummies for both regressions in column 3 are displayed in Figure 3. Also, Table 5 displays the average annual increase in the year dummies for each regression from 1987 to 1999. The year dummies can be interpreted as relative (log) residuals, that is, as the portion of the hazard rate not explained by the observed right hand variables. Trends in the residuals indicate the portion of the growth in firm litigation hazards that is not explained by these variables. In particular, column 3 includes variables that correspond to many of the obvious explanations for the increase in litigation: patent portfolio variables capture the increase in patenting rates, R&D and capital variables capture the increase in both types of investment, market value variables capture otherwise unobserved changes in “innovative fertility” and other sources of firm value, employment

\[20\] Table 4 regressions also included industry dummies but these were not displayed because their standard errors are substantially larger than those in Table 5.
variables capture changes in firm scale, and the closeness-weighted measure capture changes in technological density.

The residual growth rates and the pattern shown in Figure 3 clearly show that most of the increase in both litigation hazards is not explained by these factors. The residual accounts for most (68%) of the 5.5% annual growth rate in the hazard of being a patentee litigant and most (75%) of the 8.4% annual growth rate in the hazard of being an alleged infringer.

In column 3, the log of market value per employee captures otherwise unobserved differences in the value of firms’ technologies. Another way to capture these is by using forward patent citations, although this does reduce the sample size. Column 4 shows a regression with the adjusted (for patent class) mean number of forward citations for each firm’s patent portfolio.\footnote{Having a more highly cited patent portfolio does make a firm more likely to sue; it also makes a firm more likely to be sued. The latter finding may suggest that some portion of causation runs from litigation to patent characteristics rather than the other way. Firms that anticipate that they will become involved in litigation may prosecute their patents more intensively by making more citations. And patents that are litigated may receive more subsequent citations because they are identified as being particularly dangerous prior art. As discussed above, Table 1 provides some limited evidence for these conjectures.} Having a more highly cited patent portfolio does make a firm more likely to sue; it also makes a firm more likely to be sued. The latter finding may suggest that some portion of causation runs from litigation to patent characteristics rather than the other way. Firms that anticipate that they will become involved in litigation may prosecute their patents more intensively by making more citations. And patents that are litigated may receive more subsequent citations because they are identified as being particularly dangerous prior art. As discussed above, Table 1 provides some limited evidence for these conjectures.

Table 6 repeats the regressions from column 2 of Table 5 for different sub-samples (we also added a dummy variable for newly public firms). The first pair of columns conducts the regressions separately for firms in SIC 28 (chemical and pharmaceutical industries) and for a group industries where strategic patenting behavior has been observed (SIC 35, 36, 38 and 73, machinery including computers, electronics, instruments and business services including software). One difference that stands out is that patent portfolio size tends to be a relatively stronger determinant of litigation in the latter group while R&D tends to be a stronger influence in chemicals and pharmaceuticals. This is, perhaps, not surprising given the relative importance the “thicket” industries place on patent portfolios. Consistent with Hypothesis 4a, the larger R&D coefficients in pharma may suggest that rivals treat each others’ R&D spending as strategic substitutes.

The second comparison is between large and small firms. Generally, both patents and R&D tend to be more strongly associated with litigation among large firms than among small.

Finally, the last pair of columns compares the regression at the beginning and end of the sample period. Although the time dummies have increased dramatically during this period, the slope coefficients have not, in general, changed significantly.

\footnote{We also ran regressions using backward citations and claims. The coefficient on backward citations was statistically significant, but small. That on claims was insignificant on both counts.}
Table 7 shows estimates of the growth rate of the residuals for different sub-samples. Here the regression is conducted from 1987-99 and includes a linear time trend instead of individual year dummies. The table reports the coefficient of the time trend (with standard error) expressed as an annual percentage rate. Only one growth rate shows a statistically significant difference from the mean: the growth rate for in the residual hazard for instrument firms as patentee litigants.

**Interpretation**

**Drivers of litigation**

Summarizing the above results, the main factors influencing litigation hazards are the scale of the firms, the number of patents held by prospective plaintiffs, the R&D performed by prospective defendants, the capital intensity of the parties, and, for the probability of litigation between a given pair of firms, the technological distance between them. Measured technological distance does not seem to matter much for the aggregate litigation hazards.

As the theoretical analysis makes clear, firm scale should be an important variable because it relates to the magnitude of what the firms have at stake in litigation. The importance of the prospective plaintiff’s patent portfolio size underlines the importance of refinement—firms can improve their prospects in patent disputes by building a larger patent portfolio among other things.

The significance of prospective defendants’ R&D spending emphasizes the costs that imperfect patents can impose on innovators. Firms do not appear to spend this R&D substantially to invent around others’ patents. Instead, the act of performing innovative R&D places a firm at greater risk of being sued for infringement, perhaps because poorly defined and uncertain patent boundaries make orderly processes of clearance and licensing too difficult.

All of these factors discussed so far affect both the hazard of patent disputes and the hazards of patent litigation. Capital intensity may only affect the choice between settlement and litigation. Firms with high capital fixed costs appear to be more reluctant to engage in litigation, perhaps because they are at greater risk of holdup.

**The effect of patent portfolio size**

The data in Table 2 imply that litigation imposes a much larger burden on small firms. Lanjouw and Schankerman (2004) find evidence of large differences in litigation rates per patent across size groups. Our evidence affirms theirs and, in addition, we find evidence that small firms have much higher rates of litigation as alleged infringers per R&D dollar.
Lanjouw and Schankerman suggest that this “portfolio size effect” may be due to two forms of strategic interaction: patent trading where firms with large patent portfolios more easily cross-license and settle rather than litigate, and repeated interaction between large firms, also inducing more frequent settlement. These explanations attribute the size effect to the interaction between the firms—there is less litigation when the alleged infringer is able to retaliate with a countersuit using its own patents either in the disputed market or, given repeated interactions, in other markets and at other times.

We do find significant evidence of some such interaction between firms: a firm with greater capital intensity is less likely to sue, perhaps because of the greater risk of retaliation; a firm with greater capital intensity is less likely to be sued, perhaps because such firms settle more readily. But some thumbnail calculations suggest that differences in capital intensity cannot explain the portfolio size effect.

We also find some evidence of patent trading and defensive patenting. However, defensive patenting only seems to play a limited role reducing litigation between firms that are technologically close. The size of the defendant’s portfolio does not reduce litigation hazard in the aggregate.

Instead, our regressions suggest that there may be a more basic explanation for the portfolio size effect that does not depend on strategic interaction between firms, namely, that there may be diminishing returns to patent portfolio size. In all of our regressions, the coefficient on the plaintiff’s patent portfolio size is well below one. Of course this ignores the effect of the plaintiff firm’s size. Our regressions cannot fully distinguish between the effect of the plaintiff’s scale, which may affect litigation because it changes the plaintiff’s stake, and the direct effect of patent portfolio size. But even assuming that the coefficient on log employment is entirely due to the greater number of patents held by larger firms, the sum of the two coefficients in Table 5 is still significantly less than one. For example, in Column 5 the combined effect of employment and patents per employee has an elasticity of 0.86.

At first glance, the idea of diminishing returns to patent portfolio size may seem counter-intuitive. After all, if two firms merge, pooling their patent portfolios, why should this affect the rate of litigation per patent? But such a merger would affect the probability of winning a suit against a third firm—the probability of winning a suit will typically not double (see Bessen 2004 and Wagner and Parchomovsky 2004). For example, this will be the case if each patent has an independent probability of being found valid and infringed. And this means that the probability of litigation need not double either. Patent portfolio size exhibits diminishing returns to the probability of winning a suit. This means, in turn, that the probability of litigation increases less than proportionately with the plaintiff’s patent portfolio size.

This interpretation has important implications. Researchers commonly assume that the value of individual patents is independent of the other patents owned by the firm and that patent propensity (the ratio of patents to R&D) is independent of firm size. This result raises questions about these assumptions.
The growth in hazard rates

Measured firm characteristics seem to explain only a fraction of the growth in firm litigation hazards. The majority of the increase cannot be explained by the growth in patenting, either because of “innovative fertility” or because of greater patent propensity, the growth in R&D spending, the value of firm technology or growth in technological crowdedness.

What else might explain this rapid growth? We can think of two broad classes of factors: technology and legal changes. Technology might cause increased litigation if technological changes tended to erode industry norms of cooperation or mutual forbearance. For example, as technologies mature, industries often experience shake-outs. This might give rise to sales of patents to “trolls” by distressed firms or to anti-competitive actions by established firms, both possibly increasing litigation. However, this explanation seems unlikely, given that the growth of the residual in Table 7 does not vary sharply across industries. It does not seem likely that all industries experienced shakeouts in the 90s.

Another technological factor might be the greater use of general purpose technologies. Suppose that firms in a wide variety of industries began using general purpose technologies more intensively and they also patented these technologies. This might lead to greater litigation for two reasons: first, firms might be more likely to innocently infringe because they do not search applications outside of their own industry as intensively (and there may be many more patents to search); second, inter-industry disputes might be less likely to settle because disputants are not likely to interact repeatedly.

One candidate for such general purpose technology patents is software, which, of course, also went through a change in legal status. Software patents are obtained across a wide variety of industries and are used in a wide variety of applications. Using a definition of software patent from Bessen and Hunt (2004), we found that software patents accounted for 3% of the main patents litigated in 1984 and 17% in 1999. Moreover, note that some of the industries that use software do tend to have somewhat higher residual growth rates in Table 7, especially as alleged infringers. So software patents contributed to the growth in the litigation residual, however, this does not seem to be the main factor, especially since, again, Table 7 indicates that all industries exhibited substantial growth in the residual.

This leaves various legal changes as the likely candidates for the dominant factors affecting the growth in the litigation residual. Landes and Posner (2003, Chapter 12) suggest that the creation of a unified appeals court for patent cases increased the uncertainty of legal outcomes instead of improving the predictability of patent law, leading to increased litigation. Our results are consistent with this view, especially greater “noise” regarding the interpretation of standards of patentability and vaguer boundaries of patent claims.
Another factor may have been a pro-patentee shift in the law. Such a shift might lead to more litigation (although in some circumstances it might just lead to less infringement). Litigation may have become more attractive if the risk of patent invalidation (e.g., for obviousness) were decreased. Lunney (2004) presents evidence of just such a switch—reviewing appellate decisions, he finds a sharp decrease in the portion of patents found invalid, although he also finds an increase in the portion of patents found not to be infringed (see also Henry and Turner, 2005).

These legal changes would tend to affect firms in all industries, consistent with our estimates. And the fact that the rapid growth in litigation began after 1987—just five years after the creation of the Court of Appeals for the Federal Circuit—adds weight to this interpretation. Thus, barring some explanation we have not considered, legal changes seem to be the dominant factor accounting for the rapid rise in litigation.

Conclusion

Most of the rapid increase in patent litigation hazards over the 90s cannot be explained by firm patenting rates, R&D spending, firm value or industry composition. Looking at a variety of explanations, we conclude that legal changes may be the dominant factor driving this increase. This implies that the increase in patent litigation represents a growing disincentive to R&D that is not likely offset by growth in the number or value of innovations.

Furthermore, we find evidence that this disincentive is borne by firms not only in their roles as patent holders, but also as innovators having to defend against patent lawsuits. We find that the more R&D a firm performs, the more likely it is to be sued. In most industries, this pattern of litigation is inconsistent with the view that most defendants in patent lawsuits are simple pirates or imitators. Instead, patent defendants are, to a large degree, innovators themselves, spending as much on R&D as the plaintiffs. Moreover, about a quarter of patent lawsuits occur between firms that are in different industries and are also “technologically distant,” suggesting that innovating firms may be unable to completely “clear” their technology for possible infringement in advance. Thus an important part of the burden of patent disputes falls on defending firms. This distinction is important because although the rate of litigation per patent among public firms as plaintiffs did not increase much from 1987 to 1999, the rate of litigation per R&D dollar among public firms as defendants increased 70%.

Also, as Lanjouw and Schankerman (2004) find, the risk of litigation falls disproportionately on small firms. However, this does not appear to be mainly the result of better dispute resolution among large firms through patent trading and “defensive” patenting. We find that the defendant’s portfolio size has, at best, only a limited effect on the probability of litigation, mainly among firms that are
technologically close. Any optimism that “defensive” patenting might serve to reduce the growth of litigation is probably misplaced.

Finally, our results shed some light on the changes in litigation hazards, but our results are limited in that they say nothing about the actual costs associated with filing lawsuits and subsequent litigation and the effects of these costs on R&D. Nevertheless, there is cause for concern. Event studies find that the joint market value of plaintiffs and defendants falls by 2-3% on the filing of a patent lawsuit (Bhagat et al. 1994, Lerner 1995), suggesting that the economic burden on litigants may be substantial. So the recent doubling of litigation hazards may well impose substantial costs.

References


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Allison, John R., Mark Lemley, Kimberly A. Moore, and Derek Trunkey. 2004. “Valuable Patents,” 
*Georgetown Law Review*.


# Tables and Figures

Table 1. Sample Characteristics

<table>
<thead>
<tr>
<th></th>
<th>All Firms</th>
<th>All Patenters</th>
<th>All Litigants</th>
<th>Litigants by type</th>
<th>Alleged Infringers</th>
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<tr>
<td>R&amp;D</td>
<td>37.6</td>
<td>69.8</td>
<td>244.8</td>
<td>261.9</td>
<td>307.1</td>
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<tr>
<td>Employment</td>
<td>5.2</td>
<td>10.0</td>
<td>23.7</td>
<td>24.4</td>
<td>28.5</td>
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<td>Sales</td>
<td>846.7</td>
<td>1933.9</td>
<td>5147.6</td>
<td>5382.7</td>
<td>6195.5</td>
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<td>Portfolio size</td>
<td>44.1</td>
<td>92.7</td>
<td>375.8</td>
<td>424.6</td>
<td>442.7</td>
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<td>Portfolio adjusted claims/patent</td>
<td>3.0</td>
<td>2.8</td>
<td>2.9</td>
<td>2.5</td>
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<tr>
<td>Portfolio adjusted cites made/patent</td>
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<td>2.2</td>
<td>2.4</td>
<td>2.1</td>
<td></td>
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<tr>
<td>Portfolio adjusted cites rec'd/patent</td>
<td>3.1</td>
<td>3.5</td>
<td>3.8</td>
<td>3.2</td>
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<td>Newfirm</td>
<td>38%</td>
<td>22%</td>
<td>19%</td>
<td>16%</td>
<td>19%</td>
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<td>No R&amp;D</td>
<td>70%</td>
<td>31%</td>
<td>21%</td>
<td>16%</td>
<td>22%</td>
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<td>No Patents</td>
<td>77%</td>
<td>13%</td>
<td>8%</td>
<td>16%</td>
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<table>
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<th>Medians</th>
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<td>R&amp;D</td>
<td>2.9</td>
</tr>
<tr>
<td>Employment</td>
<td>0.5</td>
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<tr>
<td>Sales</td>
<td>64.9</td>
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<tr>
<td>Portfolio size</td>
<td>0</td>
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</table>

Note: Litigants exclude firms in retail and wholesaling industries and in SIC 6794, patent holding & franchising companies. 118,495 observations from 1984-99. Employment is in thousands. R&D and sales are deflated by the GDP deflator. New firms are observations where the firm has been listed in Compustat for five or fewer years. Portfolio size is the number of patents granted over the previous eight years.
Table 2. Litigation Hazards for firms with Patent Portfolios and Positive R&D

<table>
<thead>
<tr>
<th></th>
<th>As Patentee Litigant</th>
<th>As Alleged Infringer</th>
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<tr>
<td></td>
<td>Expected Suits per year</td>
<td>Suits per 1000 patents</td>
</tr>
<tr>
<td>All Firms</td>
<td>0.223</td>
<td>11.8</td>
</tr>
<tr>
<td>1987</td>
<td>0.198</td>
<td>10.5</td>
</tr>
<tr>
<td>1999</td>
<td>0.271</td>
<td>11.7</td>
</tr>
<tr>
<td>Small firms (employment&lt;500)</td>
<td>0.079</td>
<td>42.5</td>
</tr>
<tr>
<td>Large firms (employment&gt;=500)</td>
<td>0.304</td>
<td>10.7</td>
</tr>
<tr>
<td>New firms</td>
<td>0.114</td>
<td>30.3</td>
</tr>
</tbody>
</table>

BY INDUSTRY

<table>
<thead>
<tr>
<th></th>
<th>As Patentee Litigant</th>
<th>As Alleged Infringer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Expected Suits per year</td>
<td>Suits per 1000 patents</td>
</tr>
<tr>
<td>Chemicals/pharmaceuticals</td>
<td>0.334</td>
<td>14.4</td>
</tr>
<tr>
<td>Machinery/computers</td>
<td>0.217</td>
<td>13.0</td>
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<td>Electronics</td>
<td>0.202</td>
<td>8.8</td>
</tr>
<tr>
<td>SIC 3674</td>
<td>0.216</td>
<td>7.8</td>
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<tr>
<td>Instruments</td>
<td>0.216</td>
<td>17.6</td>
</tr>
<tr>
<td>Other manufacturing</td>
<td>0.230</td>
<td>10.3</td>
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<tr>
<td>Business svcs/software</td>
<td>0.108</td>
<td>8.4</td>
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<td>Retail/wholesale</td>
<td>0.021</td>
<td>5.9</td>
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<tr>
<td>Other non-manufacturing</td>
<td>0.141</td>
<td>8.0</td>
</tr>
</tbody>
</table>

Note: 20,522 observations from 1984-99 for firms with positive patent portfolio size and positive R&D. R&D figures are deflated by the GDP deflator. Raw hazard rates have been adjusted for underreporting (divided by .64).

Table 3. Lawsuits by technological closeness and industry overlap

<table>
<thead>
<tr>
<th>Technological Closeness</th>
<th>No industry overlap</th>
<th>Weakly overlapping industries</th>
<th>Same primary industry</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distant</td>
<td>24%</td>
<td>28%</td>
<td>11%</td>
<td>63%</td>
</tr>
<tr>
<td>Close</td>
<td>4%</td>
<td>15%</td>
<td>18%</td>
<td>37%</td>
</tr>
<tr>
<td>Total</td>
<td>28%</td>
<td>43%</td>
<td>29%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Note: For 680 lawsuits where parties on both sides are public firms. Firms in the retail and wholesale industries have been excluded. “Same primary industry” means both parties primary business is in the same 4-digit SIC industry. “Weakly overlapping industries” means the parties had a business segment in the same 3-digit SIC industry. “Distant” and “close” refer to a closeness measure >=.5 and <.5 respectively.
Table 4. Logit regression of probability of suit

<table>
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<th></th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<tbody>
<tr>
<td><strong>Patentee litigant</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log patents/employee</td>
<td>0.40 (0.07)</td>
<td>0.38 (0.07)</td>
<td>0.45 (0.09)</td>
<td>0.41 (0.07)</td>
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<tr>
<td>Ln patent/emp * distant</td>
<td>0.35 (0.08)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Ln patent/emp * close</td>
<td>0.43 (0.08)</td>
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<tr>
<td>Zero patents dummy</td>
<td>-1.62 (0.62)</td>
<td>-1.31 (0.62)</td>
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<tr>
<td>Log employment</td>
<td>0.54 (0.03)</td>
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<td>0.47 (0.04)</td>
<td>0.53 (0.03)</td>
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<td>Log R&amp;D/employee</td>
<td>0.00 (0.09)</td>
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<td></td>
<td>-0.12 (0.09)</td>
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<td>No R&amp;D dummy</td>
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<td>0.27 (0.42)</td>
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<tr>
<td>Log Mkt. Value/employee</td>
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<td></td>
<td></td>
<td></td>
<td>-0.23 (0.13)</td>
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<tr>
<td>Log capital/employee</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td><strong>Alleged Infringer</strong></td>
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<tr>
<td>Log patents/employee</td>
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<td>0.00 (0.11)</td>
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<td>0.25 (0.08)</td>
<td>0.18 (0.08)</td>
<td>0.18 (0.08)</td>
<td>0.25 (0.08)</td>
<td>0.13 (0.10)</td>
</tr>
<tr>
<td>No R&amp;D dummy</td>
<td>0.12 (0.38)</td>
<td>0.15 (0.39)</td>
<td>0.19 (0.39)</td>
<td>0.17 (0.38)</td>
<td>0.32 (0.39)</td>
</tr>
<tr>
<td>Log employment</td>
<td>0.39 (0.04)</td>
<td>0.28 (0.04)</td>
<td>0.28 (0.04)</td>
<td>0.39 (0.04)</td>
<td>0.13 (0.09)</td>
</tr>
<tr>
<td>Log Mkt. Value/employee</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.30 (0.09)</td>
</tr>
<tr>
<td>Log capital/employee</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.26 (0.13)</td>
</tr>
<tr>
<td><strong>Interaction terms</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>plaintiff ln pat/emp*defendant ln pat/emp</td>
<td></td>
<td></td>
<td></td>
<td>-0.03 (0.03)</td>
<td></td>
</tr>
<tr>
<td>Technological closeness</td>
<td>2.35 (0.24)</td>
<td>2.47 (0.38)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Number of obs</strong></td>
<td>1,240,580</td>
<td>1,240,580</td>
<td>1,240,580</td>
<td>1,240,580</td>
<td>994,148</td>
</tr>
<tr>
<td><strong>Log likelihood</strong></td>
<td>-1568.9</td>
<td>-1522.8</td>
<td>-1521.3</td>
<td>-1568.6</td>
<td>-1400.4</td>
</tr>
</tbody>
</table>

Note: Logit regressions with industry and year dummies not shown. Asymptotic standard errors in parentheses. Patents are the portfolio size, that is, the number of patents granted the previous 8 years. Dummy variables report zero patents and zero R&D. R&D and market value are deflated by the GDP deflator, capital is property, plant and equipment deflated by the NIPA capital goods deflator, and employment is in thousands. Technological closeness measure is described in text.
Table 5. Poisson regressions of expected number of suits per year

<table>
<thead>
<tr>
<th>Expected suits as patentee litigant</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log portfolio size</td>
<td>0.39 (0.02)</td>
<td>0.37 (0.02)</td>
<td>0.36 (0.02)</td>
<td>0.40 (0.03)</td>
</tr>
<tr>
<td>Portfolio=0 dummy</td>
<td>-1.46 (0.14)</td>
<td>-1.41 (0.15)</td>
<td>-1.20 (0.21)</td>
<td></td>
</tr>
<tr>
<td>Portfolio size missing</td>
<td>-0.98 (0.19)</td>
<td>-0.89 (0.19)</td>
<td>-0.91 (0.20)</td>
<td></td>
</tr>
<tr>
<td>Log R&amp;D/emp.</td>
<td>0.10 (0.03)</td>
<td>-0.06 (0.03)</td>
<td>0.09 (0.03)</td>
<td></td>
</tr>
<tr>
<td>R&amp;D not reported</td>
<td>-0.30 (0.11)</td>
<td>-0.39 (0.11)</td>
<td>0.04 (0.12)</td>
<td></td>
</tr>
<tr>
<td>Log employment</td>
<td>0.47 (0.01)</td>
<td>0.51 (0.02)</td>
<td>0.51 (0.02)</td>
<td></td>
</tr>
<tr>
<td>Log capital/emp.</td>
<td>-0.23 (0.03)</td>
<td>-0.40 (0.04)</td>
<td>-0.33 (0.05)</td>
<td></td>
</tr>
<tr>
<td>Log mkt. Value/emp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log other firms' patents</td>
<td>-0.02 (0.11)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log other firms' R&amp;D</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adj. Cites rec'd/patent</td>
<td></td>
<td></td>
<td></td>
<td>0.017 (0.003)</td>
</tr>
<tr>
<td>Chemicals/pharmaceuticals</td>
<td>1.18 (0.19)</td>
<td>0.86 (0.19)</td>
<td>0.82 (0.20)</td>
<td>0.73 (0.22)</td>
</tr>
<tr>
<td>Machinery/computers</td>
<td>0.88 (0.18)</td>
<td>0.46 (0.19)</td>
<td>0.57 (0.20)</td>
<td>0.31 (0.22)</td>
</tr>
<tr>
<td>Electronics</td>
<td>0.95 (0.18)</td>
<td>0.55 (0.19)</td>
<td>0.66 (0.20)</td>
<td>0.34 (0.22)</td>
</tr>
<tr>
<td>Instruments</td>
<td>1.20 (0.19)</td>
<td>0.74 (0.20)</td>
<td>0.82 (0.21)</td>
<td>0.59 (0.24)</td>
</tr>
<tr>
<td>Other manufacturing</td>
<td>0.63 (0.17)</td>
<td>0.42 (0.17)</td>
<td>0.47 (0.17)</td>
<td>0.28 (0.20)</td>
</tr>
<tr>
<td>Business svcs/software</td>
<td>0.52 (0.21)</td>
<td>-0.05 (0.23)</td>
<td>0.00 (0.23)</td>
<td>-0.12 (0.29)</td>
</tr>
<tr>
<td>Retail/wholesale</td>
<td>-0.80 (0.26)</td>
<td>-1.05 (0.27)</td>
<td>-0.81 (0.28)</td>
<td>-0.64 (0.40)</td>
</tr>
<tr>
<td>Residual growth (sample: 5.5%)</td>
<td>4.0%</td>
<td>4.7%</td>
<td>3.7%</td>
<td>6.1%</td>
</tr>
<tr>
<td>Log likelihood =</td>
<td>-9751.1</td>
<td>-9645.3</td>
<td>-9035.3</td>
<td>-7187.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Expected suits as alleged infringer</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log portfolio size</td>
<td>0.10 (0.02)</td>
<td>0.11 (0.02)</td>
<td>0.11 (0.02)</td>
<td>0.17 (0.02)</td>
</tr>
<tr>
<td>Portfolio=0 dummy</td>
<td>-0.75 (0.09)</td>
<td>-0.76 (0.09)</td>
<td>-0.60 (0.11)</td>
<td></td>
</tr>
<tr>
<td>Portfolio size missing</td>
<td>-1.23 (0.12)</td>
<td>-1.19 (0.12)</td>
<td>-1.13 (0.12)</td>
<td></td>
</tr>
<tr>
<td>Log R&amp;D/emp.</td>
<td>0.26 (0.02)</td>
<td>0.28 (0.02)</td>
<td>0.15 (0.03)</td>
<td>0.25 (0.03)</td>
</tr>
<tr>
<td>R&amp;D not reported</td>
<td>-0.23 (0.09)</td>
<td>-0.22 (0.09)</td>
<td>-0.29 (0.09)</td>
<td>0.11 (0.11)</td>
</tr>
<tr>
<td>Log employment</td>
<td>0.48 (0.01)</td>
<td>0.50 (0.01)</td>
<td>0.53 (0.01)</td>
<td>0.53 (0.01)</td>
</tr>
<tr>
<td>Log capital/emp.</td>
<td>-0.12 (0.02)</td>
<td>-0.30 (0.03)</td>
<td>-0.23 (0.04)</td>
<td></td>
</tr>
<tr>
<td>Log mkt. Value/emp.</td>
<td></td>
<td></td>
<td></td>
<td>0.35 (0.03)</td>
</tr>
<tr>
<td>Log other firms' patents</td>
<td></td>
<td></td>
<td></td>
<td>0.12 (0.09)</td>
</tr>
<tr>
<td>Log other firms' R&amp;D</td>
<td></td>
<td></td>
<td></td>
<td>-0.10 (0.10)</td>
</tr>
<tr>
<td>Adj. Cites rec'd/patent</td>
<td></td>
<td></td>
<td></td>
<td>0.014 (0.003)</td>
</tr>
<tr>
<td>Chemicals/pharmaceuticals</td>
<td>0.65 (0.13)</td>
<td>0.53 (0.13)</td>
<td>0.49 (0.13)</td>
<td>0.18 (0.14)</td>
</tr>
<tr>
<td>Machinery/computers</td>
<td>0.55 (0.12)</td>
<td>0.36 (0.13)</td>
<td>0.48 (0.13)</td>
<td>-0.02 (0.14)</td>
</tr>
<tr>
<td>Electronics</td>
<td>0.79 (0.12)</td>
<td>0.61 (0.12)</td>
<td>0.70 (0.13)</td>
<td>0.18 (0.14)</td>
</tr>
<tr>
<td>Instruments</td>
<td>1.04 (0.13)</td>
<td>0.84 (0.13)</td>
<td>0.89 (0.14)</td>
<td>0.40 (0.14)</td>
</tr>
<tr>
<td>Other manufacturing</td>
<td>0.43 (0.10)</td>
<td>0.30 (0.10)</td>
<td>0.34 (0.11)</td>
<td>-0.09 (0.12)</td>
</tr>
<tr>
<td>Business svcs/software</td>
<td>0.01 (0.15)</td>
<td>-0.26 (0.16)</td>
<td>-0.26 (0.16)</td>
<td>-0.49 (0.22)</td>
</tr>
<tr>
<td>Retail/wholesale</td>
<td>0.85 (0.11)</td>
<td>0.61 (0.12)</td>
<td>0.75 (0.12)</td>
<td>0.70 (0.22)</td>
</tr>
<tr>
<td>Residual growth (sample: 8.4%)</td>
<td>6.7%</td>
<td>7.2%</td>
<td>6.3%</td>
<td>8.5%</td>
</tr>
<tr>
<td>Number of obs</td>
<td>93,333</td>
<td>87,856</td>
<td>76,843</td>
<td>15,811</td>
</tr>
<tr>
<td>Log likelihood =</td>
<td>-10253.4</td>
<td>-10153.9</td>
<td>-9318.8</td>
<td>-6014.5</td>
</tr>
</tbody>
</table>

Note: Regressions are Poisson regressions with year dummies and independent variables lagged one year. Standard errors are heteroscedastic robust. R&D and market value are deflated by the GDP deflator, capital is property, plant and equipment deflated by the NIPA capital goods deflator, and employment is in thousands. Cites received is adjusted for mean for patent class. Residual growth is annual growth rate of time dummies.
Table 6. Separate Litigation Poisson Regressions  
Dependent Variable: Number of lawsuits as Patentee Litigants or Alleged Infringers

<table>
<thead>
<tr>
<th>Lagged independent variables</th>
<th>Industry Group</th>
<th>Firm Employment Size</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Chemicals &amp; pharmaceuticals</td>
<td>Thicket Industries</td>
<td>&lt;500</td>
</tr>
<tr>
<td><strong>Patentee Litigants</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log portfolio size</td>
<td>0.23 (0.06)</td>
<td>0.38 (0.03)</td>
<td>0.28 (0.06)</td>
</tr>
<tr>
<td>Portfolio=0 dummy</td>
<td>0.14 (0.35)</td>
<td>-1.39 (0.21)</td>
<td>-1.13 (0.26)</td>
</tr>
<tr>
<td>Portfolio size missing</td>
<td>-0.91 (0.48)</td>
<td>-0.96 (0.32)</td>
<td>-1.03 (0.26)</td>
</tr>
<tr>
<td>Log R&amp;D/emp.</td>
<td>0.41 (0.07)</td>
<td>-0.04 (0.04)</td>
<td>-0.12 (0.05)</td>
</tr>
<tr>
<td>R&amp;D not reported</td>
<td>-0.33 (0.56)</td>
<td>-0.29 (0.18)</td>
<td>-0.80 (0.27)</td>
</tr>
<tr>
<td>Log capital/emp.</td>
<td>-0.43 (0.09)</td>
<td>-0.02 (0.05)</td>
<td>-0.20 (0.09)</td>
</tr>
<tr>
<td>Log employment</td>
<td>0.74 (0.04)</td>
<td>0.45 (0.02)</td>
<td>0.49 (0.07)</td>
</tr>
<tr>
<td>Newly public firm</td>
<td>-0.45 (0.23)</td>
<td>0.28 (0.13)</td>
<td>0.28 (0.14)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. Observations</td>
<td>5345</td>
<td>26684</td>
<td>43464</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>-1451</td>
<td>-4692</td>
<td>-2480</td>
</tr>
</tbody>
</table>

| **Alleged Infringers**      |                |                      |      |      | 5345   | 26684 |
| Log portfolio size          | 0.04 (0.06)    | 0.18 (0.02)          | 0.02 (0.05) | 0.14 (0.02) | 0.12 (0.03) | 0.11 (0.02) |
| Portfolio=0 dummy           | -0.43 (0.35)   | -0.59 (0.13)         | -0.56 (0.21) | -1.06 (0.11) | -0.96 (0.14) | -0.66 (0.11) |
| Portfolio size missing      | -0.41 (0.46)   | -1.32 (0.22)         | -1.42 (0.20) | -1.08 (0.14) | -1.27 (0.19) | -1.16 (0.14) |
| Log R&D/emp.                | 0.36 (0.06)    | 0.20 (0.03)          | 0.20 (0.05)  | 0.31 (0.03)  | 0.27 (0.04)  | 0.28 (0.03)  |
| R&D not reported            | -1.68 (0.61)   | 0.04 (0.15)          | -0.30 (0.26) | -0.07 (0.09) | -0.21 (0.14) | -0.17 (0.11) |
| Log capital/emp.            | -0.25 (0.09)   | 0.07 (0.04)          | -0.06 (0.06) | -0.15 (0.03) | -0.15 (0.04) | -0.10 (0.03) |
| Log employment              | 0.60 (0.03)    | 0.47 (0.02)          | 0.40 (0.06)  | 0.51 (0.02)  | 0.50 (0.02)  | 0.51 (0.01)  |
| Newly public firm           | 0.02 (0.23)    | 0.03 (0.09)          | 0.31 (0.11)  | 0.10 (0.09)  | 0.16 (0.11)  | 0.14 (0.08)  |
|                            |                |                      |      |      | 5345   | 26684 |
| No. Observations            | 5345           | 26684                | 43464 | 44458 | 40518  | 47404 |
| Log likelihood              | -1209          | -4497                | -2415 | -7648 | -3804  | -6352 |

Note: Regressions are Poisson regressions with year dummies, industry dummies and independent variables lagged one year. Standard errors are heteroscedastic robust. R&D, cashflow and market value are deflated by the GDP deflator, capital is property, plant and equipment deflated by the NIPA capital goods deflator, and employment is in thousands. The “new firm” dummy is equal to one for the first five years a firm appears in Compustat. Thicket industries are SIC 35, 36, 38 and 73.
Table 7. Annual Growth Rate of Residual for Sub-samples

<table>
<thead>
<tr>
<th>Category</th>
<th>As patentee litigant</th>
<th>As alleged infringer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemicals/pharmaceuticals</td>
<td>2.9% (2.4)%</td>
<td>7.4% (1.9)%</td>
</tr>
<tr>
<td>Machinery/computers</td>
<td>5.7% (1.9)%</td>
<td>8.3% (1.7)%</td>
</tr>
<tr>
<td>Electronics</td>
<td>6.6% (2.3)%</td>
<td>2.9% (1.8)%</td>
</tr>
<tr>
<td>Instruments</td>
<td>9.3% (1.9)%</td>
<td>7.2% (1.9)%</td>
</tr>
<tr>
<td>Other manufacturing</td>
<td>6.2% (1.5)%</td>
<td>7.7% (1.3)%</td>
</tr>
<tr>
<td>Business services/software</td>
<td>2.3% (4.7)%</td>
<td>9.2% (4.0)%</td>
</tr>
<tr>
<td>Retail/wholesale</td>
<td>8.1% (6.3)%</td>
<td>4.3% (2.7)%</td>
</tr>
<tr>
<td>Other non-manufacturing</td>
<td>-1.1% (4.2)%</td>
<td>6.8% (2.6)%</td>
</tr>
<tr>
<td>New firms</td>
<td>7.8% (2.2)%</td>
<td>5.4% (1.7)%</td>
</tr>
<tr>
<td>Incumbent firms</td>
<td>3.9% (1.0)%</td>
<td>6.3% (0.7)%</td>
</tr>
<tr>
<td>Small firms</td>
<td>5.1% (1.8)%</td>
<td>5.7% (1.7)%</td>
</tr>
<tr>
<td>Large firms</td>
<td>4.4% (1.0)%</td>
<td>6.4% (0.7)%</td>
</tr>
<tr>
<td><strong>ALL</strong></td>
<td>4.3% (0.9)%</td>
<td>6.1% (0.7)%</td>
</tr>
</tbody>
</table>

Note: Regressions are Poisson regressions with linear year trend from 1987-99. Independent variables are lagged one year. Standard errors, in parentheses, are heteroscedasticity robust. New firms (incumbent firms) have been listed in Compustat for five years or fewer (more). Small firms (large firms) have fewer than 500 employees (more).
Figure 1. Patent Lawsuits Filed Annually (Derwent data from USPTO)

Figure 2. Equilibrium Regions
Figure 3. Residual Time Trends for Litigation Hazards from Table 5, Column 3.