

WORTHLESS PATENTS

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Patent value is an illusive concept. What makes a patent valuable? There are at least two kinds of value with regard to patents: valuable inventions and valuable patents. A patent on a foundational development in a new field is one of great societal value and often referred to as a pioneering patent.² These patents may or may not generate significant revenue for their inventors or assignees.³ A patent of great private value is a patent which provides some advantage to its owner regardless of the advance for society.

Each year the United State Patent & Trademark Office (PTO) receives 350,000 patent applications⁴ and grants approximately 180,000 patents.⁵ Despite the large

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² See, e.g., Alan Cohen, *10 Patents That Changed the World*, IP WORLDWIDE, Aug. 2002, at 27 (identifying ten active patents “that have made a big difference—shaking up society for better or worse”).

³ The most pioneering of inventions such as the first patent on cloning or the first transistor patent may be so ground breaking that a commercial market or commercial applications for the technology may not exist for several years. Cf. Dan L. Burk & Mark A. Lemley, *Policy Levers in Patent Law*, 89 VA. L. REV. 1575, 1656 (2003) (“It is a venerable principle of patent law that pioneering patents--important patents that open up a new field--should be entitled to a broader range of protection than more modest inventions or improvements on existing ideas.”). But see *Plant Genetic Systems, N.V. v. DeKalb Genetics Corp.*, 315 F.3d 1335, 1341 (Fed. Cir. 2003) (stating that arguments that the *Hogan* case held that “pioneering inventions ‘deserve broad claims to the broad concept,’” are taken out of context and are “extended dicta”).

⁴ Patent filings have risen dramatically in recent years. See U.S. Patent Statistics available at http://www.uspto.gov/web/offices/ac/ido/oeip/taf/us_stat.pdf (demonstrating that the number of patent applications in the U.S. filed has doubled in the last ten years).

⁵ Each year the number of patents issued rises substantially. See *id.* (showing that patent grant rates have increased by 80% in the last ten years). The PTO does not seem to be able to keep pace with the rise in application filings. See Victoria Slind-Flor, *Bar Reacts to Bezos Patent Reform Plan*, NAT'L L.J., Mar. 27, 2000, at A1 (quoting Representative Coble: “If everyone would keep their grubby hands off the PTO's fees,

number of patent grants annually only 2000 patent litigations involving 3000 patents are filed each year to enforce patents against infringers in the district courts. So what happens to the other 177,000 patents granted each year? Are unlitigated patents valuable or is the patent system a very expensive lottery?⁶

Certainly litigated patents are not the only valuable patents. Unlitigated patents may be valuable as defensive measures, as deterrents, for signaling purposes, or generate revenue through licensing without ever being litigated. Patents may be valuable for defense rather than offense either standing alone or in large numbers.⁷ The defensive patenting strategy, like the arms race, focuses on a deterrent theory. Don't sue me on your patents or I'll sue you on mine. This often results in cross licensing. The defensive

the agency could hire and retain even more examiners to ensure that only quality patents are issued."). Alternatively, perhaps the lower grant rate reflects a PTO which has become more selective (stricter) in applying patent requirements. *But see* Cecil D. Quillen, Jr. et al., *Continuing Patent Applications and Performance of the U.S. Patent and Trademark Office—Extended*, 12 FED. CIR. B.J. 35, 38 (2002) (suggesting that the PTO issues over 85% of all applications that are filed).

⁶ "A patent is not unlike an expensive lottery ticket; you pay your money up front and hope for the big payoff." Jonathan A. Barney, *A Study of Patent Mortality Rates: Using Statistical Survival Analysis to Rate and Value Patent Assets*, 30 AIPLA Q.J. 317, 328 n.30 (2002). *See also* A. Samuel Oddi, *The Tragicomedy of the Public Domain in Intellectual Property Law*, 25 HASTINGS COMM. & ENT. L.J. 1 (2002) (analogizing the race to patent to a lottery); JOHN JEWKES ET AL., *THE SOURCES OF INVENTION* 188 (2d ed. 1969) (The patent system is wasteful and lacks logic. "Its critics have described the patent right as merely 'something which has to be defended in the courts' and, because it may put the individual inventor at a disadvantage against the larger corporations, as 'a lottery in which it is hardly worth while taking out a ticket."); F.M. Scherer, *The Innovation Lottery: The Empirical Case for Copyright and Patents*, in EXPANDING THE BOUNDS OF INTELLECTUAL PROPERTY: INNOVATION POLICY FOR THE KNOWLEDGE SOCIETY (Rochelle Cooper Dreyfuss et al. eds. 2001). *Cf.* Allan N. Littman, *Restoring the Balance of Our Patent System*, 37 IDEA 545, 564 (1997) (analogizing patent litigation to a lottery system).

⁷ *See, e.g.*, Kimberly A. Moore, *Xenophobia in American Courts*, 97 NW. U. L. REV. 1497, 1532-33 (2003) (discussing defensive use of patents); Jean O. Lanjouw & Mark Schankerman, *An Empirical Analysis of the Enforcement of Patent Rights in the United States* (working paper 2002) at 4 ("Patentees with a large portfolio of patents to trade . . . more successfully avoid court actions."); John H. Barton, *Reforming the Patent System*, 287 SCIENCE 1933 (2000) (discussing this defensive patenting practice); Mark A. Lemley, *Reconceiving Patents in the Age of Venture Capital*, 4 J. SMALL & EMERGING BUS. L. 137, 143 (2000) ("One of the major reasons that companies get patents is that they're afraid that their competitors have them, and they don't want to be the only one left who doesn't have the ability to play in this game."); William A. Tanenbaum, *Current Topics in Software Licensing*, 620 PLI/PAT 97, 111-12 (2000) ("If you are sued for patent infringement, and you have your own patent, you may be able to settle or head off the suit altogether by having the parties cross-license their patents to each other without paying any damages.").

patenting strategy may also take the form of patent blocking⁸ or a patent thicket.⁹ Patents may also be valuable in deterring competition more directly. Patents may deter market entry because competitors refrain from competing with patented products to avoid infringement charges which secures patentee market shares. Patents may also be valuable as signaling mechanisms.¹⁰ The patent may be valuable as giving some form of imprimatur to a product's quality or superiority over other products, such as a shampoo's

⁸ Blocking patents typically involve the hold up by a pioneer or improver to mutually beneficial development and cross-licensing. See Nicholas Groombridge & Sheryl Calabro, *Integra Lifescience v. Merck—Good Research or Just Good for Research Tool Owners*, 22 BIOTECH. L. REP. 462, 470 (2003) (defining blocking patents as “a refusal by a single patent holder to grant a license on acceptable terms [which] could stymie the entire line of research”); John H. Barton, *Antitrust Treatment of Oligopolies with Mutually Blocking Patent Portfolios*, 69 ANTITRUST L.J. 851 (2002) (discussing blocking patents); Robert Merges, *Intellectual Property Rights and Bargaining Breakdown: The Case of Blocking Patents*, 62 TENN. L. REV. 75, 79-82(1994) (giving examples of blocking patents); Robert P. Merges, *A Brief Note on Blocking Patents and the Reverse Doctrine of Equivalents in Biotechnology Cases*, 73 J. PAT. & TRADEMARK OFF. SOC'Y 878, 883 (1991). See also Bronwyn H. Hall & Rosemarie Ham Ziedonis, *The Patent Paradox Revisited: An Empirical Study of Patenting in the U.S. Semiconductor Industry, 1979-1995*, 32 RAND J. ECON. 101, 104 (2001) (finding that semiconductor manufacturers seem to be motivated to patent not by a desire to “win strong legal rights to a stand alone technical prize” but rather they engage in “patent portfolio races” to avoid being held up by external patent owners).

⁹ Patents are often sought by companies not just on the products that they actually sell, but on every conceivable variation of the product in order to block competition more generally. The term patent thicket generally refers to the existence of horizontal overlap among patents which results in multiple parties being able to lay claim to the same invention. ADAM B. JAFFE & JOSHUA LERNER, *INTO THE PATENT THICKET* 76-77 (forthcoming Princeton University Press 2004) (draft on file with author); James Bessen, *Patent Thickets: Strategic Patenting of Complex Technologies* (2003) (working paper) (explaining patent thickets); Carl Shapiro, *Navigating the Patent Thicket: Cross Licenses, Patent Pools, and Standard Setting*, in 1 INNOVATION POLICY AND THE ECONOMY 119, 121 (Adam B. Jaffe et al. eds., 2001) (defining the term patent thickets).

¹⁰ Jaffe & Lerner, *supra* note 9, at 19 (“Patents, trademarks and other forms of intellectual property represent a ‘currency’ that is used increasingly to demonstrate to financial markets, suppliers, and customers that a firm is a strong player, and can be expected to achieve a dominant position.”); Clarisa Long, *Patent Signals*, 69 U. CHI. L. REV. 625, 651-53 (2002) (discussing how patents may be useful mechanisms to convey information about the invention and the firm such as productivity, innovation activity and firm size and to signal low future rent discounts); Mark A. Lemley, *Reconceiving Patents in the Age of Venture Capital*, 4 J. SMALL & EMERGING BUS. L. 137, 144 (2000) (explaining use of patents to differentiate companies and products or to act as “internal yardsticks for progress in research and development”). A recent study by Kortum and Lerner suggests that there is a strong positive relationship between venture capital financing and patenting. Samuel Kortum & Josh Lerner, *Does Venture Capital Spur Innovation?* Nat'l Bureau of Econ. Res. Working Paper No. W6846, (Dec. 1998), available at <<http://papers.nber.org/papers/w6846> (“[W]e find that the amount of venture capital activity in an industry significantly increases its rate of patenting.”).

patented volumizing formula.¹¹ A large patent portfolio may alternatively signal technical superiority to consumers, competitors and venture capitalists.¹² Finally, it may, of course, be the case that patents are licensed routinely without the need for litigation.¹³

¹¹ See, e.g., <http://www.psychemedics.com/corp.htm> (advertising “World's Largest, Patented Provider of Hair Testing for Drugs of Abuse”); <http://www.steamspecialist.com/enrj6.htm> (advertising ENRJ™ is the only state of the art, patented, high energy Fuel Homogenization System”); http://www.samsung.com/Products/Monitor/LCDMonitor/Monitor_LCDMonitor_172T.htm (advertising that “All SyncMaster monitors come outfitted with *the patented Kensington Security Lock compliant hardware*, to ensure that your monitor is protected from theft, even in wide-open, public areas”).

¹² Hall & Ziedonis, *supra* note 8, at 104 (finding that strong patent rights are especially critical to specialized semiconductor design firms which entered the market after 1982 to attract venture capital funding and secure proprietary rights in niche product markets). It is not uncommon for companies to advertise their large patent portfolios as a signal of their technical dominance or superiority. For example, the IBM website proudly proclaims:

IBM Leads the pack in patents. In 2003, IBM received 3,415 U.S. patents from the USPTO. This is the eleventh consecutive year that IBM has received more U.S. patents than any other company in the world. In addition to delivering these innovations through its products and services, IBM maintains an active patent and technology licensing program.

<http://www.ibm.com/ibm/licensing/patents/portfolio.shtml> The General Electric website similarly brags:

You’ve probably heard of Thomas Edison. The founder of GE and one of the most accomplished and respected inventors in history, he set the global standard for innovation and creativity. Today, our inventors continue in Edison’s footsteps, making their own mark with inventions that improve lives around the world.

Our researchers collectively hold thousands of patents. In fact, over the past 20 years at least 180 patents have been issued annually to GE Global Research researchers. In the last year alone, we were awarded 263 patents.

<http://www.crd.ge.com/cooltechnologies/patentleaders.jsp> Even a single patent, if it shows a company ahead in a technological race could discourage competitors from even attempting to compete. Cf. Gideon Parchomovsky, *Publish or Perish*, 98 MICH. L. REV. 926, 932 (2000) (arguing that in a patent race competitors may behave strategically by publishing parts of an invention as a signal to their competitors or to reduce the payoff to their competitor’s patenting); Douglas Lichtman et al., *Strategic Disclosure in the Patent System*, 53 VAND. L. REV. 2175 (2000) (discussing and disputing Parchomovsky’s claims).

¹³ According to a recent report, “companies are more willing than ever before to buy rights to knowledge,” and, in 1998 alone, “U.S. companies earned \$100 billion from licensing fees.” Edward Kahn, *Recognizing and Licensing IP: Why It's Important for Small Companies*, THE INTELL. PROP. STRATEGIST, Dec. 2000, at 8. For example, the Cohen-Boyer patent on gene splicing generated upwards of \$155 million in licensing revenue and is considered “one of the most valuable patents in history,” yet this patent was never litigated. See Oren Bar-Gill & Gideon Parchomovsky, *The Value of Giving Away Secrets*, 89 VA. L. REV. 1857, 1871 (2003). Once a company has shown its willingness to enforce its patents by bringing one litigation and winning, other competitors may license this and other patents more readily. See Jaffe & Lerner, *supra* note 9, at 74 (suggesting that that Texas Instruments’ \$800 million in licensing revenue annually (about 55% of its total net income) may be attributable to its willingness to enforce its patents in the early 1990s).

It may even be the case that the patents that are litigated are weaker, more prone to challenge, than the patents where competitors acquiesce and license without opposition.¹⁴

Although patent value may be an illusive concept to nail down, because of the differing ways in which a patent can be valuable and the impossibility of obtaining sufficient empirical data on each,¹⁵ patent worthlessness may, on the other hand be more easily quantified.

Many commentators have opined that patent quality has declined substantially in recent years.¹⁶ Does the PTO issue a significant number of worthless patents? Given the high costs of patent preparation and prosecution, why do companies pursue worthless patents? Preparation and prosecution of a patent application by a patent attorney costs

¹⁴ Although from an economic perspective, this argument makes sense, if companies behave rationally they will license the stronger patents asserted against them, refuse to license the weak ones, and litigate only the close cases, akin to the selection effect theory. See George L. Priest & Benjamin Klein, *The Selection of Disputes for Litigation*, 13 J. LEGAL STUD. 1, 4-5 (1984). However, patent litigation, where injunctions are often preferred by the patentee over licensing fees often eliminates overlap in settlement range. As a result, the selection of cases that go to trial are not likely to mirror the 50/50 Priest-Klein prediction. *Id.* Moreover, the selection of cases that are initiated, because of the low transaction costs associated with bringing a lawsuit and imperfect information informing the parties' expectations, seem even less likely to model the Priest-Klein selection effect theory. The Priest/Klein model seems more likely to mirror trial outcome rates where the transaction costs are much higher and where discovery has informed the parties improving their ability to predict the strength of suits initiated.

¹⁵ Obtaining a database of litigated patents in any given time period is possible, and in fact, we did just this for the 6861 patents that were involved in litigation that terminated between 1999 and 2000. See John R. Allison, et al., *Valuable Patents*, 92 GEO. L. J. (forthcoming 2004) [hereinafter *Valuable Patents*]. Obtaining a database of all patents which are licensed or all patents which are used as signals, or all patents that companies think contribute to their defense, seems like an impossible task both because of the volume of licensing agreements and their secrecy.

¹⁶ See, e.g., Robert P. Merges, *As Many as Six Impossible Patents Before Breakfast: Property Rights for Business Concepts and Patent System Reform*, 14 BERKELEY TECH. L.J. 577, 589 (1999) (discussing why patent quality is so poor); John R. Thomas, *Collusion and Collective Action in the Patent System: A Proposal for Patent Bounties*, 2001 U. ILL. L. REV. 305, 318 (2001) ("In combination with the declining significance of the utility and statutory subject matter requirements, meager Patent Office funding has had a felt impact upon patent quality."); Mark Lemley, *Rational Ignorance at the Patent Office*, 95 NW. U. L. REV. 1496, 1495 (2001) (arguing that "the PTO has come under attack of late for failing to do a serious job of examining patents, thus allowing bad patents to slip through the system"); David Streitfeld, *Note: This Headline is Patented*, L.A. TIMES, Feb. 7, 2003 (quoting James Rogan, Director of the PTO, "This is an agency in crisis, and it's going to get worse"; further stating "'Crisis is a strong word,' the American Intellectual Property Law Association has noted in correspondence, 'but we believe that it aptly describes the situation.'").

anywhere from \$5,000 for a simple invention to hundreds of thousands of dollars for complex inventions.¹⁷ The fees to the PTO are a small portion of the overall cost.¹⁸

Despite these costs, there are a significant number of patents that issue each year which are criticized for their absurdity.¹⁹ There are many websites²⁰ and even magazine columns²¹ devoted to chronicling such patents. For example, issued U.S. patents have claimed an animal toy which would include a tree branch,²² a face mask to prevent a person from eating,²³ a bird diaper,²⁴ an apparatus for simulating a “high five,”²⁵ an air conditioning unit for a shoe (to keep one’s feet cool),²⁶ a hat simulating a fried egg,²⁷ a

¹⁷ See Thomas, *supra* note 16, at 345 (stating that attorney charge several thousand dollars for preparing simple patent applications and considerably more for complex applications or applications involved in appeals or interferences). Cf. Lemley, *supra* note 16, at 138 (“What this means if you multiply it out is that more than two million patents are now in force in the United States. If you do a little math and you know how much it actually costs to get a patent through the entire system, it’s pretty easy to see that in the United States alone, the prosecution costs--what we’re paying patent prosecutors and the PTO--exceed \$5 billion a year, to say nothing of the costs in the rest of the world, the costs of litigation, or any of the costs of licensing.”)

¹⁸ The PTO currently charges applicants \$300 to file a patent application and \$1400 to issue a patent. PTO Fees and Payment of Money, 37 C.F.R. §§1.16(a), 1.18(a) (2004). These fees are cut in half for small entities – that is any individual, non-profit corporation, or corporation which qualifies as a small business under the Small Business Act. *Id.*

¹⁹ James Glieck, *Patently Absurd*, N.Y. TIMES MAG., March 12, 2000, available at <http://www.around.com/patent.html>; Lawrence Lessig, *The Problem With Patents*, THE INDUSTRY STANDARD, Apr. 23, 1999, available at <http://www.thestandard.com/article/0,1151,4296,00.html>.

²⁰ See, e.g., Totally Absurd Inventions available at <http://totallyabsurd.com/absurd.htm>; Bizarre Patents available at www.patscan.ca; Crazy Patents available at <http://www.crazypatents.com/>; Delphion’s Gallery of Obscure Patents available at <http://www.delphion.com/gallery>.

²¹ In fact, there is a column in Scientific American entitled *Staking Claims: You Can Patent That?* which discusses patents issued each month which according to the author “transcend the mundane.” Gary Stix, *Staking Claims: You Can Patent That?*, SCIENTIFIC AMERICAN, July 2003.

²² U.S. Patent No. 6,360,693 (issued Mar. 26, 2002).

²³ U.S. Patent No. 4,344,424 (issued Aug. 17, 1982).

²⁴ U.S. Patent No. 5,934,226 (issued Aug. 10, 1999).

²⁵ U.S. Patent No. 5,356,330 (issued Oct. 18, 1994).

²⁶ U.S. Patent No. 5,375,430 (issued Dec. 27, 1994).

method of swinging on a swing,²⁸ an electronic toilet queue,²⁹ a dust cover for a dog³⁰ and a method of exercising a cat by using a laser pointer (like a flashlight) on the floor and moving the beam of light so the cat chases it.³¹ At least the Federal Circuit recently affirmed the PTO's denial of patent claims to a crustless-peanut-butter-and-jelly sandwich.³² Most lay people could, with little difficulty, conclude that these patents are worthless. Although these may qualify as worthless patents in the empirical study presented in this article, worthlessness is not determined according to a subjective standard or impression of an invention's merit.

This article uses a more objective and systematic way to quantify the value of patents. After a patent issues, the fees to the PTO do not end. The patentee is required to pay maintenance fees at three intervals during the life of a patent.³³ Three and a half years after issuance, a patentee must pay \$900 or the patent will expire at the four year point. Seven and a half years after issuance, the patentee must pay \$2300 or the patent

²⁷ U.S. Patent No. 5,457,821 (issued Oct. 17, 1995).

²⁸ U.S. Patent No. 6,368,227 (issued Apr. 9, 2002).

²⁹ U.S. Patent No. 6,329,919 (issued Dec. 11, 2001). Even large corporations like IBM, which filed this patent, seek patents with marginal economic value and social utility.

³⁰ U.S. Patent No. 3,150,641 (issued Sept. 29, 1964).

³¹ U.S. Patent No. 5,443,036 (issued Aug. 22, 1995).

³² While an initial patent was awarded to Smuckers for the crustless PB&J sandwich, broader application claims to the process of making the PB&J sandwich were rejected by the PTO and affirmed by the Federal Circuit. *See* U.S. Patent No. 6,004,596.

³³ In contrast to the U.S., where renewal fees are only paid three times over the life of the patent, most countries require annual renewal fees. Additionally, unlike most countries, the U.S. has reduced application and renewal fees for small entities. One consistency is that renewal fee structures always increase over the life of the patent. *Cf.* Joshua S. Gans, et al, *Patent Renewal Fees and Self-Finding Patent Offices*, working paper (on file with author) ("Economists have found the rising fee structure to be a desirable feature of the patent renewal process.").

will expire at the eight year point, and eleven and a half years after issuance, the patentee must pay \$3800 or the patent will expire at the twelve year point.³⁴ Even though there is a uniform patent term for all patents, twenty years from the date of the application,³⁵ renewal fees create a de facto differentiation in patent terms. It is hard to imagine that just four years after paying \$10,000-\$30,000 for preparation and prosecution of a patent application, the successful patentee would decide to let the patent expire rather than pay the \$910 maintenance fee. Nevertheless, this empirical study has found that 53.71% of all patentees do allow their patents to expire for failure to pay their maintenance fees.³⁶ Even more interesting is the finding that the patents which expire for failure to pay maintenance fees share some common identifiable characteristics. No other empirical scholarship in the legal or economic literature has ever considered the characteristics of expired patents as a measure of their innovative output.³⁷

This article provides a means of systematically identifying worthless patents.³⁸ Such analysis compliments the author's earlier work on identifying valuable patents³⁹

³⁴ 37 C.F.R. §1.127(a) (2004). The maintenance fees for small entities are halved. *Id.* If a patent expires due to non-payment of maintenance fee, it can be "unexpired" if the patentee convinces the PTO that the late payment was either unavoidable or unintentional. 37 C.F.R. §1.378 (2004).

³⁵ 35 U.S.C. §154.

³⁶ Obviously, patentees understand the economic idea of sunk costs and are willing to cut their losses.

³⁷ The economics literature has not entirely overlooked expiration data. There are studies examining U.S. and foreign renewal data for purposes of evaluating innovative output. *See, e.g.*, Gans, et al, *supra* note 32 (finding that self-funding patent offices have incentive to distort patent application and renewal fees in ways that are detrimental to social welfare); Jean O. Lanjouw, et al., *How to Count Patent and Value Intellectual Property: The Uses of Patent Renewal and Application Data*, 46 J. INDUSTRIAL ECON. 405 (1998) (presenting a model using patent counts and renewal data as a measure of the extent of innovation).

³⁸ We acknowledge that our definition of value in this paper corresponds to long term patent value. Our definition necessarily assumes that the longer the patentee continues to maintain the patent the longer the patent is valuable, i.e. the more valuable the patent is. Of course, it must be acknowledged that for certain types of technology (fast moving fields), patent value may be realized very quickly. *See infra* Part II.

³⁹ *Valuable Patents*, *supra* note 15.

giving a richer sense of how to measure a patent's worth. Part I of this article, details the empirical study, its compilation, the methodology used to analyze the data, and the results. Part II interprets and explains the results. It also considers the implications of these findings for evaluating the efficacy of Intellectual Property Rights policy and innovation incentives. Finally, Part III compares the findings of this study to our recent study on litigated patents concluding that many of the same patent characteristics that predict the likelihood that a patent will be maintained also predict the likelihood that a patent will be litigated and that renewal rate data is a better predictor of patent value because it captures the many forms of private value that may be conferred by a patent (defensive, deterrent and signaling) as well as revenue generation.

I. The Empirical Study

A. Data Collection

In an attempt to quantify or qualify patent value, I collected an original dataset of all of the 96,713 utility patents issued from the PTO in 1991. Although 1991, might at first blush, seem like an odd or even outdated selection of year, 1991 is the most recent year of patent issuance for purposes of analyzing patents that expire for failure to pay maintenance fees.⁴⁰ Patents can expire for failure to pay maintenance fees four, eight or twelve years after issuance.⁴¹ Hence looking at patents that issued in 1991, permits

⁴⁰ Another nice feature of using patents issued in 1991 is that all of these patents have a patent term of seventeen years from their issuance date. 35 U.S.C. §154. Patents filed after June 8, 1995, have a patent term of twenty years from their filing date, which means a patent patents may not still be enforceable twelve years after issuance (if they were pending at the PTO for eight or more years). Even if they still exist at the twelve year point, if they are going to expire at year thirteen or fourteen, rather than year seventeen or twenty there may be less of an incentive to pay the twelve year maintenance fee. This issue does not exist with the patents issued in 1991.

⁴¹ See *supra* note 33 and accompanying text.

examination of whether these patents expire at the four year point (1995), eight year point (1999) or twelve year point (2003). Selecting a year of patent issuance more recent than 1991 would not permit examination of patent fee payments over their entire life. Nonetheless, we did examine whether more recently issued patents shared the same characteristics at their four year points, and found our results replicated.

For each of the patents issued in 1991, we searched the weekly issues of the Patent Office Gazette for 1995, 1999, and 2003 to ascertain whether they expired due to their owner's failure to pay maintenance fees. A list of the 51,949 patents that did expire for failure to pay maintenance fees was collected.⁴² Table 1 below shows the break down of expired patents.

We also collected detailed characteristic information on the patents, the inventors, and the assignees. In particular, we collected data on patent grant date, patent filing date, whether the patent claims priority to other U.S. applications, the number of such claims to priority, and the earliest priority date claimed. I combined this original dataset with additional patent characteristic data such as the number of claims, number of forward and backward citations, number of inventors, whether the inventors are foreign or domestic, whether the patent is assigned at the time of issuance, whether the assignee is a U.S. corporation, foreign corporation, U.S. individual, foreign individual, the U.S. government or a foreign government, and general technology classifications (based on the PTO's

⁴² Actually a larger number of patents expired for failure to pay maintenance fees, but 988 of these patents were reinstated as of March 23, 2004. The PTO allows patent reinstatement if the failure to pay was due to an unavoidable or unintentional delay. To show unintentional delay, the patentee has to file a reinstatement petition within 24 months after the 6 month grace period. For unavoidable delay, the patentee has to promptly file a petition after receiving notice or becoming aware of expiration of patent. 37 C.F.R. §1.378 Hence for the 988 patents that were reinstated, we treated them as if they had never expired. Since there is a two year window in which patents can be reinstated, there could be additional reinstated patents through 2005. There were also a number of corrections "errata" made by the PTO regarding the patent number of the expired patents. We adjusted the data to properly account for each of the reported corrections.

technology classification system). This patent characteristic data was derived from the extensive empirical work of Bronwyn Hall, Adam Jaffe, and Manual Trajtenberg available through the National Bureau of Economic Research.⁴³

B. Statement of Hypothesis and Description of Empirical Model

In order to determine whether there were any observable indicia of a patent's value or a patent's lack of value, we compared the expired and unexpired patents across a large number of variables. In particular, we examined the following characteristics to determine whether they impacted the likelihood that a patent owner would fail to pay maintenance fees: the number of claims (Claims), the number of prior art U.S. patents that were considered by the examiner before the patent was issued (Cites Made), the number of U.S. patents that issued after this patent and cited it as relevant prior art (Cites Received), the length of time a patent spent in prosecution from its filing date to its grant date (Application Time) and the length of time a patent spent in prosecution from its earliest claim of priority to its grant date (Prosecution Time), the number of total applications in the chain that led to this one that issued (Number of Related Applications), the number of inventors listed on the patent (Inventors), the percentage of the inventorship entity that is foreign (Percent Foreign), whether the patent is unassigned at the time of issuance (Unassigned) or if assigned whether it is assigned to a U.S. Corporation, Foreign Corporation, U.S. Individual, Foreign Individual, U.S. Government, or Foreign Government, the data are also broken down into seven different fields of technology namely, Chemicals, Communications and Computers, Drugs and Medicine, Electrical and Electronics, Mechanical, and Other. Recognizing that there are

⁴³ Bronwyn Hall, et al., *The NBER Patent Citation Data File: Lessons, Insights and Methodological Tools*, NAT'L BUREAU ECON. RES., Working Paper No. 8498 (2001).

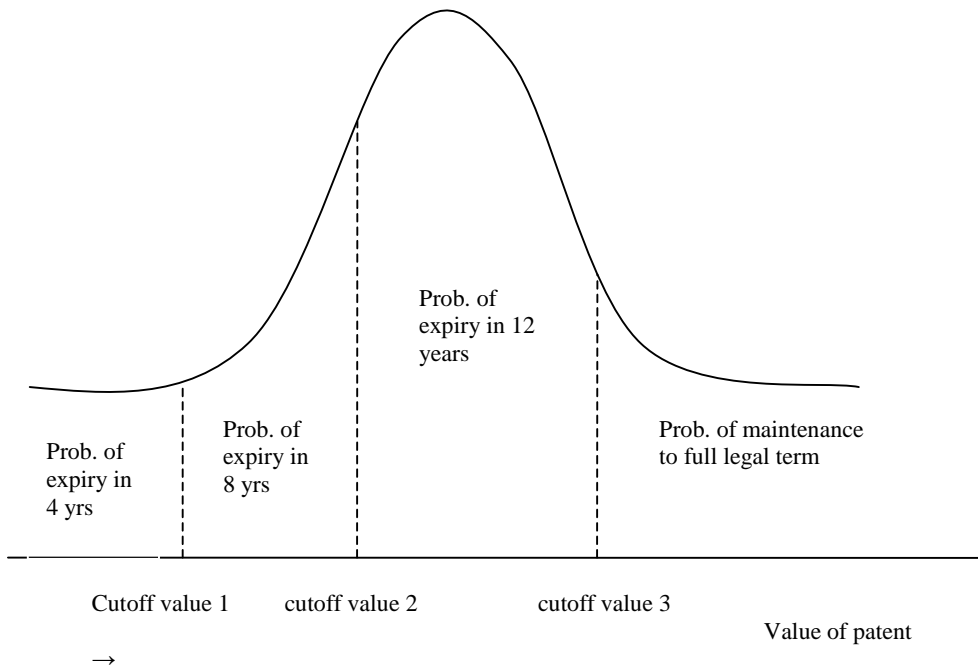
shortcomings with such broad technology classifications, in a finer analysis we broke technology classifications into thirty-six different technologies.⁴⁴

We hypothesize that the unobserved value of a patent is a function of certain observable characteristics.⁴⁵ To test our hypothesis, we present descriptive statistics on the various patent characteristics, comparisons of the means, but since descriptive statistics do not account for the relationships among variables, we also formulated an ordered logit model which starts out by assuming that patent values are randomly distributed according to the logistic distribution. Less valuable (or worthless) patents are more likely to expire earlier and valuable patents are more likely to be maintained to their full legal term.

⁴⁴ We recognize that in addition to the problems inherent in broad technology classifications, namely that pharmaceuticals and medical device patents which are grouped together may for example be very different in nature, there is another shortcoming of this classification system. This classification grouping is based on the PTO technology classification system. There are 400 different PTO technology classifications. Commentators have observed that the PTO technology classes do not group all similar technology together and as a result, may not be ideal for distinguishing among technologies. See John R. Allison & Mark A. Lemley, *Who's Patenting What? An Empirical Exploration of Patent Prosecution*, 53 VAND. L. REV. 2099, 2114 (2000) (explaining the shortcomings of the PTO classification system for distinguishing among types of technologies); John R. Allison & Mark A. Lemley, *The Growing Complexity of the U.S. Patent System*, 82 B.U. L. REV. 77, 92 (2002) (same); John R. Allison & Emerson H. Tiller, *The Business Method Patent Myth*, 18 BERKELEY TECH. L.J. 987, 1027-28 (2003) (criticizing the PTO and IPC classifications systems as not identifying technology areas, but instead functioning at a very low level of abstraction).

⁴⁵ In our earlier work on patent characteristics, we discussed the characteristics that economists have used to predict patent value: claims, citations made, citations received, generality, originality, and IPC classifications. *Valuable Patents*, *supra* note 15. We found that the first three characteristics were unambiguously strong predictors of patent litigations, while the others were not. *Id.* See Part III *infra* for a more detailed comparison of patent characteristics in the *Valuable Patents* study and this study.

Figure 1: Distribution of Patent Value.



Our model then estimates three cut-off points⁴⁶ which divide the probability distribution into four regions such that patents with values less than the first cut-off point expire in 4 years, patents with values in between the first and second cutoff points expire in 8 years, patents with values between the second and third cut-off points expire in twelve years and patents with values greater than the third cut-off value are maintained to their full legal term of twenty years.

To determine the relationship between patent characteristics and the value of the patent, we specified an ordered logit model. An ordered logit model is used when the dependent variable is unobserved but has an inherent ranking⁴⁷ such as in the instant case,

⁴⁶ The cut-off points roughly correspond to the cutoff value of the patent. It is important to note that since value is unobserved the estimates are simply ordinal transforms of the actual unobserved value of the patent.

⁴⁷ See GREENE, W.H.: ECONOMETRIC ANALYSIS 926-28 (3d ed. 1997).

where the value of patents that expired within four years is less than the value of patents that expire in eight years which are in turn less valuable than patents that expire in twelve years and so on. The dependent variable is given a coded value of 1 if the patentee pays all the maintenance fees at the intervals specified by the PTO and therefore remains unexpired until its full legal term. It takes the coded value of 2 if the patent expired at the end of twelve years, a coded value of 3 if the patent expired at the end of eight years and a value of 4 if the patent expired at the end of four years due to non-payment of maintenance fees at the specified intervals. The non-linear estimation technique used allows for estimation of cut-off values for each category and determines which patent characteristics are statistically significant predictors of patent value.

II. Empirical Results and Their Meaning

A. Descriptive Statistics

The data used in this study correspond to the population of 96,713 patents issued in 1991. Table 1 shows the mean patent characteristics by category. More than half (53.71%) of the patents issued in 1991 expired before their full term due to non-payment of maintenance fees. The results indicate that:

- Expired patents had fewer claims than patents that were maintained to the full term. Patents that expired earlier (four years) had fewer claims than patents that expired later (eight years, twelve years).

- Expired patents cited fewer U.S. patent prior art references than unexpired patents.⁴⁸ And, patents that expired earlier, in general, cited fewer U.S. patent prior art references than patents that expired later.
- Expired patents received fewer citations than patents that were maintained to the full term. The longer the patent was maintained, the greater the number of citations it received.
- Expired patents also listed a fewer number of inventors than patents that were maintained.
- Expired patents had fewer related applications than unexpired patents. Patents that expired earlier had fewer related applications than patents that expired later.

Variable	All Unexpired Patents	Patents expired in 12 years	Patents expired in 8 years	Patents expired in 4 years	All Expired Patents
Total Number of Patents	44,764	16,095	20,340	15,514	51,949
Percent of Total	46.29%	16.64%	21.03%	16.04%	53.71%
Claims	13.27	12.63	11.95	11.44	12.01
Percent Foreign	0.47	0.51	0.47	0.44	0.47
Citations Made	7.79	7.52	7.54	7.39	7.49
Citations Received	7.13	5.49	4.67	4.03	4.73
Inventors	2.14	2.07	1.99	1.82	1.96
Related Applications	0.38	0.33	0.29	0.27	0.30
Application Time	1.75	1.69	1.69	1.71	1.70
Total Prosecution Time	2.32	2.18	2.13	2.10	2.14

⁴⁸ We refer to patents that were maintained to the full legal term as unexpired patents.

1. Characteristics of the Patent

The finding that the lower the number of claims, the number of prior art references cited on the patent, the number of related applications, and the prosecution time, the more likely the patent is to expire is consistent with our intuition. Patents with more claims are more expensive to file and prosecute.⁴⁹ These patents would also be more intimidating to potential infringers as more claims may mean more chances that the patent is infringed⁵⁰ and the harder the patent will be to invalidate.⁵¹ Hence patents with more claims are simply more valuable.

Patents with more U.S. patent prior art cited during their prosecution are likely more expensive for the patentee to prosecute. Prior art is cited on a patent if it is either found by the examiner during the examiner's own search or disclosed to the examiner by the inventor. The more prior art that is cited on the patent, the more extensively (in theory) the patent was examined by the examiner and the more difficult the patent will be

⁴⁹ The patent application fee covers a total of twenty claims (three of which may be independent). If the applicant wishes to file more than twenty claims or more than three independent claims they must pay an additional per claim fee. 37 C.F.R. §1.16(c). Of course, the application fee is small compared to the expense of having an attorney draft and prosecute the claims. *See supra* note 17 and accompanying text.

⁵⁰ With claim construction being such an amorphous concept and high reversal rates for claim construction at the Federal Circuit, the more different ways that the same invention is claimed, the more likely it is that the court will agree with the patentee that one of the claims is infringed. *See* Kimberly A. Moore, *Are District Court Judges Equipped to Resolve Patent Cases?*, 15 HARV. J. L. & TECH. 1 (2001) (finding that district court claims constructions are reversed by the Federal Circuit 33% of the appeals). More claims means more bites at the apple for the patentee. Of course, this is not to say that a patent with five claims is necessarily broader than a patent with one claim. Moore, *Xenophobia*, *supra* note 7, at 1543-44.

⁵¹ Patents with more claims are likely harder to invalidate for two reasons. First, each additional dependent claim is narrower than the independent claim upon which it is based and the narrower the claim, the harder it will be to find prior art which discloses all of the same claim limitations. Second, even if the additional claims are not narrower, they will be of a different scope and use different claim language again making invalidation more difficult.

to invalidate.⁵² The data support the notion that patents with more prior art are more valuable.⁵³

The higher the number of related applications the more expensive this invention was for the inventor to protect. Of course, with each new application, continuation, continuation-in-part or divisional, comes additional application fees and prosecution expenses.⁵⁴ We measure related applications in a limited and admittedly imperfect way. An application is considered related if it is cited in the priority chain on the front face of the patent. This means that parent and grandparent applications upon which an applicant may be relying for priority would count as related applications, but other original applications which the same inventor may have filed separately on the same or similar technology would not count.⁵⁵ Consistent with our intuition, the larger the number of applications that the inventor has already filed on this invention, the more likely they are to pay their maintenance fees, the more invested they are in the technology and its protection. A patent with many relatives may simply evidence the inventor's

⁵² With the presumption of validity that attaches to issued patents, 35 U.S.C. § 282, and the reluctance of judges and juries to second guess the PTO, the expert agency that granted the patent, the more prior art that is cited on a patent, the harder it is to invalidate.

⁵³ It must be acknowledged that the citation of a large number of U.S. patent prior art references means that this invention is likely not a pioneering invention, but rather an improvement in a crowded field. Which means that intuitively it would seem that patents that issue in a field where there are already many other patents, are not likely to be as broad as patents on newer technology, and therefore less valuable in general. However, since few patents actually issue to truly pioneering inventions, most patents are improvements in a crowded art and among those patents it makes sense that the ones that have been more carefully vetted by the PTO would be more valuable.

⁵⁴ A request for continuing examination is like filing a new application and incurs another \$770 fee. *See* 37 C.F.R. § 1.114.

⁵⁵ A patent portfolio race or a patent family is generally considered to be more than just a chain of applications, and generally includes several chains that are not directly related, but are based on similar technologies. Future research needs to be done on the development of a technique to identify patent families, not just related applications which could then be include in the regression would improve the accuracy of this measure.

determination to patent the invention or evidence the inventor's desire to secure many patents on the same technology to block competition broadly, in either event, it signals the importance of the patent protection to the patentee.⁵⁶

Finally, prosecution time and the number of related applications are correlated variables. Prosecution time is the total time an application and its relatives spent in the PTO being prosecuted. In particular, it is the time from the earliest claim of priority on an application to its grant date. Of course, the larger the number of related applications in the chain, the longer the prosecution time.⁵⁷ Hence, patents with longer prosecution time are more valuable to their owner because prosecution time is correlated with the number of related applications. There is no relationship between application time (time from filing to issuance) and patent expiration which suggests that the number of years an application spends in the PTO is not itself an indicator of how valuable the patent is to its owner.

Whether it is the fact that a patent with more claims and which cites more prior art references is more valuable because of these characteristics (more makes it better) or the case that patentees routinely file more claims and cite more prior art when an underlying invention and its protection are more important to the patentee, differences exist between the kinds of patents which are likely to expire early and those which will be maintained.

⁵⁶ Since the number of related applications and the characteristics of the assignee were included in the regression, this mitigates concerns that maintenance fee data may not be a good indicator of individual patent value in light of the fact that large entities pay maintenance fees on portfolios of patents which are valuable as a portfolio, but not valuable as stand alone patents.

⁵⁷ Two caveats must be acknowledged. When a patent claims priority to ninety-eight different related applications, it does not necessarily take ninety-eight times longer than an application with one claim to priority. Patentees can make priority claims in the alternative, by claiming that an application is a continuation-in-part of several different other applications. For example, U.S. Patent No. 5,714,566 (issued Feb. 3, 1998) claimed priority to ninety-eight related applications. It was not, however, claiming priority to ninety-eight different applications in sequential order, but rather claiming priority to seventeen different possible application chains.

Many of the factors which signal a difference between these two types of patents are largely within the control of the inventor or patentee. The patentee decides how many claims to file, how exhaustively to search the prior art before filing, how many related applications to file and how long prosecution will be continued and each of these decisions impacts the cost of the prosecution to the patentee.

There is one factor which may be beyond the patentee's control which impacts the likelihood that a patent will be maintained. Patents which are maintained receive a larger number of cites from other subsequently issued U.S. patents than patents that expire and the longer they are maintained, the more cites they receive. Of course, a patent continues to exist as prior art whether it expires or not, so it is not the fact of the expiration that impacts citations received. Citations received tend to indicate industry interest in a particular technology. If a patent receives a large number of cites by subsequently issued patents to competitors, this suggests that the technology is one which competitors also value and it seems unlikely in a competitive environment that the patentee would allow such a patent to expire. If on the other hand the large number of cites received come from the patentee (self-citation), this indicates that the technology is so important to the patentee that they are filing subsequent patents on the same technology which again supports the conclusion that the patentee would be unlikely to allow such a patent to expire.

2. Characteristics of the Inventor and/or Patentee

The larger the number of inventors, the more likely a patent is to be maintained. This may be true for two reasons. First, with more inventors the chances that the patent continues to hold value for at least one of the inventors may be higher. Second, there is a

correlation between the number of inventors and assignment. The larger the number of inventors, the more likely the patent is to be assigned to a corporation. Table 2 shows the percent of expired or unexpired patents that were either unassigned or were assigned to various entities. Results indicate that patents that are assigned to corporations are more likely to be maintained than unassigned patents or patents assigned to individuals or government. This may reflect the differing purposes for which corporations and individuals patent. For example, corporations, more than individuals, acquire patents for deterrent, defensive or signaling purposes. Such purposes may warrant maintenance of a patent even if it is not directly generating revenue. Alternatively, corporations may simply be better at the outset at identifying and prosecuting more valuable patents.⁵⁸ It may also be the case that individuals are more attune to cost control than corporations where there may be a disconnect between those paying the maintenance fees (in-house attorneys) and those evaluating the innovation value of particular patents in the future. Finally, the stability of large corporations versus individuals and sole proprietorships may explain differences in renewal rates. The large corporation is more likely to be a viable entity twelve years after the patent issues.

Table 2: % of Patents That Expire By Class of Patentee/Assignee					
	Unexpired Patents	Patents expired in 12 years	Patents expired in 8 years	Patents expired in 4 years	Expired Patents
Un-Assigned	31.9%	14.5%	24.8%	28.8%	68.1%
US Corporation	51.5%	16.2%	19.7%	12.7%	48.5%
Foreign Corporation	48.7%	18.3%	19.7%	13.3%	51.3%
US Individual	34.2%	13.8%	26.9%	25.1%	65.8%
Foreign Individual	29.8%	17.2%	26.2%	26.9%	70.2%
US Government	35.4%	13.6%	43.0%	18.1%	74.6%

⁵⁸ This is the subject of the further research by the author. Kimberly A. Moore, *Populism and Patents* (working paper 2005) (draft on file with author) (studying the difference between individual and corporate patenting and enforcement).

Foreign Government	37.7%	15.9%	29.0%	17.4%	62.3%
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3. Characteristics of the Technology

Table 3 shows the percentage of expired or unexpired patents that belonged to each particular industry. Figure 1 below shows what percent of patents in a given industry (technology) group expired. The results confirm that patent protection as a source of private returns to inventive activity varies sharply across technology fields. Communication and computer, drug and medical, and electronics patents were all more likely to be maintained by their owners whereas mechanical patents and patents in the catch-all other category were more likely to expire. Chemical patents seemed to fall more towards the middle.

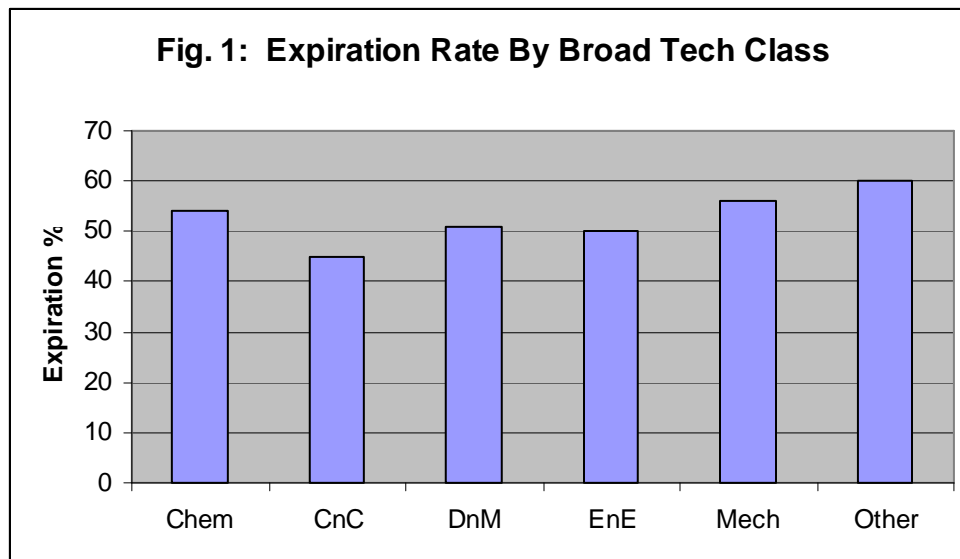


Table 3: Industry distribution by patent category (%)

	All Unexpired Patents	Patents expired in 12 years	Patents expired in 8 years	Patents expired in 4 years	All Expired Patents
Chemical industry	0.19	0.21	0.20	0.18	0.20
Communication and Computers	0.12	0.11	0.09	0.06	0.09
Drugs and Medical	0.09	0.08	0.09	0.09	0.08
Electrical and Electronics	0.19	0.18	0.17	0.15	0.16
Mechanical	0.22	0.23	0.23	0.24	0.24
Other	0.18	0.20	0.23	0.28	0.24

The fact that higher research and development costs are generally associated with pharmaceutical technology as compared to say mechanical inventions,⁵⁹ may explain why these patents are more likely to be maintained. Most of the patent term extension provisions were added for the benefit of the pharmaceutical industry.⁶⁰ Hence patent protection is a significant source of return and the magnitude of the return does vary by technology. The fact that pharmaceutical patents are more likely to be maintained, may

⁵⁹ Estimates of the average cost of drug development and testing range from \$110 million to \$500 million; the latter is the industry's figure. Compare with <http://www.phrma.org/publications/publications/profile01/chapter2.pdf> <http://www.citizen.org/Press/pr-drugs33.htm>.

Recent studies estimate that the cost of bringing a new drug to market is nearly \$800 million. This high cost is mostly due to the fact that for every 5,000 chemicals tested in animals, only five go on to human clinical testing, and of this five, only one makes it to market. Thus, a pharmaceutical company must have the financial resources to develop and test thousands of compounds, knowing that very few of them will ever reach consumers or potentially reap a profit. Due to this lottery-like effect, when a company latches on to a "winner," they must gain enough profit from that drug to fuel the continuing research and development cycle.

Sarah E. Eurek, *Hatch-Waxman Reform and Accelerated Market Entry of Generic Drugs: Is Faster Necessarily Better?*, 2003 DUKE L. & TECH. REV. 18, 20 (2003). See also Christine S. Paine, *Brand-Name Drug manufacturers Rist Antitrust Violations By Slowing Generic Products in Through Patent Layering*, 33 SETON HALL L. REV. 479, 483 (2003) ("Because of the high costs of research and development, the pharmaceutical industry views patents as an especially important form of motivation."); Thomas F. Cotter, *Introduction to IP Symposium*, 14 FLA. J. INT'L L. 147, 149 (2002) (noting that the patent incentive may be particularly important for pharmaceutical products because of the high costs of research and development).

⁶⁰ See, e.g., 35 U.S.C. §§ 155A, 156 (2003) (special term extensions for pharmaceutical patents); Robert P. Merges & Glenn H. Reynolds, *The Proper Scope of the Copyright and Patent Power*, 37 HARV. J. LEGIS. 45 (2000) (discussing efforts to extend patent terms); Robert P. Merges, *One Hundred Years of Solicitude: Intellectual Property Law, 1900-2000*, 88 CAL. L. REV. 2187, 2234 n.217 (2000) (discussing proposed extension for Claritin patent).

also be attributable to the fact that patents in these technologies are more likely to be acquired by corporations rather than individuals, and corporations are more likely to maintain their patents. While the univariate statistics are helpful in identifying possible differences, standing alone, they cannot necessarily fully explain those differences.

B. Regression Results

The results discussed so far, however, are simply descriptive statistics. They do not take into account the interrelationships of the various characteristics. The regression results presented in Table 4 estimate the effect of a particular characteristic while holding constant the effects of all other characteristics. The results indicate that the number of claims and citations received are still statistically significant predictors of patent value as measured by the probability that a patent will be maintained. The positive coefficient on claims indicates that the greater the number of claims, the more likely the patent is to be maintained to the end of its legal term. Similarly, the positive coefficient on citations received indicates that this variable also has a positive effect on the probability that the patent is maintained to the end of its term. Interestingly, the number of citations made on the patent is not a significant predictor of patent renewal. Another empirical study found that the number of citations made on the patent and the number of claims in a patent were highly correlated variables.⁶¹ It seems logical that applicants who more highly value a particular patent would be likely to file more claims and do a more thorough prior art search prior to filing. Removing the claims variable from the regression confirms that the number of citations made is then a significant predictor of likelihood of maintenance fee

⁶¹ See Allison & Tiller, *supra* note 43 (finding that in both a dataset of 1093 Internet business method patents and a dataset of 1000 general patents, citations made and number of claims was extremely highly correlated).

payment ($p=.0010$). Hence, the larger the number of citations made, the more likely maintenance fees will be paid.

Table 4: Logistic Regression Results⁶²

Variable	Estimate β	Standard Error	Significance p	Exp(β)
Claims	0.006	0.001	<.0001	1.006
Chemical - (Chem)	-0.058	0.019	0.002	0.944
Communications & Computers- (CnQ)	0.176	0.024	<.0001	1.192
Drugs & Medical- (DnM)	-0.066	0.025	0.007	0.936
Electrical & Electronics- (EnE)	0.110	0.019	<.0001	1.117
Other industries	-0.099	0.018	<.0001	0.906
Citations Made	0.001	0.001	0.378	1.001
Citations Received	0.041	0.001	<.0001	1.042
Percent foreign	-0.123	0.023	<.0001	0.884
Inventors	0.032	0.005	<.0001	1.032
US Corporation	0.717	0.018	<.0001	2.049
Foreign Corporation	0.840	0.024	<.0001	2.316
US Individual	-0.006	0.074	0.937	0.994
Foreign Individual	0.090	0.105	0.393	1.094
US Government	-0.123	0.055	0.026	0.884
Foreign Government	0.421	0.087	<.0001	1.523
Application time	-0.021	0.011	0.059	0.979
Priority time	0.038	0.009	<.0001	1.038
Related Applications	0.078	0.015	<.0001	1.082

The number of inventors, time in prosecution, and number of related applications also continue to play a significant role in patent maintenance. Most of the variables that seemed important in the descriptive statistics continue to be significant in the regression. With regard to assignment of patent rights and its impact on maintenance, we left out unassigned patents. Hence, each of the other categories is compared to unassigned

⁶² The regression includes appropriate intercepts that are not reported here.

patents. It is not surprising that patents assigned to individuals are treated the same as patents that are unassigned because an unassigned patent is basically a patent still owned by an individual (the inventors). Hence, individual behavior regarding maintenance fees is the same regardless of whether the patent remains with the individual inventors or was assigned to another individual. Corporate patenting, however, is significantly different from unassigned patents. Both U.S. and foreign corporations are much more likely to maintain the patents assigned to them (likely reflecting the different patenting strategies of individuals and corporations). In addition to an individual/corporation distinction in patent maintenance, there also exists a domestic/foreign difference. Foreign corporations are more likely to maintain their patents than U.S. corporations and foreign governments are more likely to maintain their patents than the U.S. government. Moreover, the larger the percentage of the inventorship entity that is foreign (the more foreign inventors), the more likely the patent is to be maintained.

This foreigner effect is likely due to the higher transaction costs for foreigners to patent in the U.S. Foreign parties are therefore less likely to file worthless patents; they are more selective in their patenting *ex ante*. Foreign parties have usually already put the invention through the patent system in their home country and possibly others before filing in the United States. Accordingly, the patents that they file in the U.S. are better vetted than the patents first filed in the U.S. The foreign inventors would have to disclose all of the prior art from the foreign prosecution which the U.S. examiner would have to allow the patent over. The implication being that the U.S. patents acquired by foreign inventors would therefore be stronger than those acquired by their domestic counterparts by virtue of the duplicative review process. It may also be that U.S. patents are a more

important signaling mechanism for foreign parties than their U.S. counterparts.⁶³ Or perhaps U.S. corporations are increasingly implementing internal cost-control maintenance review systems for technical obsolescence which their foreign counterparts are not doing. Put simply, that U.S. corporations are better at estimating the expected return from a given patent and therefore more adept at weeding out worthless patents via maintenance fee payments. Either way, this is a significant validation of the international flow of returns from the U.S. patent system.

With regard to technology, the mechanical group was left out of the regression. Accordingly, each of the other categories is significant if they are sufficiently different than the mechanical group. Chemical, Drugs and Medicine and Other industries are less likely to be maintained than mechanical patents. Electrical and Computer and Communication patents are more likely to be maintained than mechanical patents. Given the differences in research and development costs, these results are surprising and initially seem to call into question the long time assumption that patent rights are more important in industries with high research and development costs.⁶⁴

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⁶⁴ *Valuable Patents*, *supra* note 15 (discussing industry-specific patterns of patent value); Hall & Ziedonis, *supra* note 8 (noting the primarily defensive use of patents in the semiconductor industry); Ashish Arora et al., *R&D and the Patent Premium* 1, 33 *tbl.4* (Working Paper 2002) (demonstrating that patents give greater returns in some industries than others); Allison & Lemley, *supra* note 43, at 2146 (showing substantial variation by industry in the nature and importance of patents); Wesley M. Cohen et al., *Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or Not)*, NAT'L BUREAU OF ECON. RES., Working Paper W7552 (2000) (finding differences across industries in the use of patents relative to other methods of protecting intellectual property); Richard C. Levin et al., *Appropriating the Returns from Industrial Research and Development*, 1987 BROOKINGS PAPERS ON ECON. ACTIVITY 783, 785-86 (finding differences across industries in patents granted per dollar of research and development expenditure); Nancy S. Dorfman, INNOVATION AND MARKET STRUCTURE: LESSONS FROM THE COMPUTER AND SEMICONDUCTOR INDUSTRIES 235-39 (1987) (discussing the importance of lead-time in the computer and semiconductor industries); Edwin Mansfield, *Patents and Innovation: An Empirical Study*, 32 MGMT. SCI. 173, 176 (1986) (examining the extent to which various firms and industries rely on the patent system to protect their innovations); Mark Schankerman, *How Valuable is Patent Protection? Estimates By Technology Field*, 29 RAND J. OF ECON. 77 (1998) (finding that the private value of patent rights in France differed by technology field).

Intuition would have suggested that there are more random, and ultimately worthless, mechanical patents issued, than biotech or pharmaceutical patents. Perhaps the pharmaceutical and biotech industries are more patent-happy.⁶⁵ It may be that they rush to patent new compounds and genes (and their methods of manufacture) before knowing whether those compounds have great utility or commercial viability.⁶⁶

Recognizing that the technology categories controlled for in the regression above may be overly broad and, therefore may not allow for sufficient variation, we subdivided the technology categories into thirty-six subcategories.⁶⁷ The substantive results are the same with respect to all other characteristics (the number of claims, citations received, inventors, and assignments continue to be significant). The regression results for the technology subcategories are listed below. Biotech was left out, so it is the comparison point.⁶⁸ The results show that patents related to communications and computer technology are more likely to be maintained than biotech patents. Patents on semiconductors and electrical devices are more likely to be maintained than biotech

⁶⁵ See *Knorr-Bremse Systeme Fuer Nutzfahrzeuge GMBH v. Dana Corp.*, Brief of Amicus Curiae Biotechnology Industry Organization, at 4 (“Typical biotechnology drug development periods exceed a decade and only one in every 10,000 potential drugs that enters pre-clinical testing will receive U.S. Food and Drug Administration approval as a novel medicine.”).

⁶⁶ Michael J. Meurer, *Business Method Patents and Patent Floods*, 8 WASH. U. J.L. & POL'Y 309, 319 (2002) (noting that the “development of efficient gene sequencing technology and the Human Genome Project provided the impetus for a flood of gene discoveries and patents”).

⁶⁷ The sub-category definitions are taken from Bronwyn Hall, et al., *The NBER Patent Citation Data File: Lessons, Insights and Methodological Tools*, NAT'L BUREAU ECON. RES., Working Paper No. 8498 (2001).

⁶⁸ In a regression with qualitative explanatory variables as we have here, dummy variables are created and used to measure the impact of the each category of the qualitative variable. For instance here, we have 36 different dummy variables to represent each tech sub-category. The dummy variable takes a value of one if the patent belongs to the particular sub-category and is given a value of zero otherwise. When the regression includes an intercept term such as here, one of the dummy variables has to be dropped to avoid perfect colinearity with the intercept term. The omitted category then becomes a base or benchmark for all other categories. The dummy variable coefficients on the remaining categories measure the extent to which they differ from the base category. See PETER KENNEDY, *A GUIDE TO ECONOMETRICS* 216-18 (3d ed. MIT Press 1992).

patents. But biotech patents are more likely to be maintained than drug patents and agricultural and organic compounds patents. Biotech patents are more likely to be maintained than patents granted on simple devices (not as technically complex) which may be less expensive in terms of R&D such as amusement devices, furniture or house fixtures, apparel and textile, or receptacles. It appears that biotech patents are more likely to be maintained than most mechanical inventions suggesting that the initial break down of all technology into six categories was too broad. The optics group is the only subgroup of mechanical that is in fact more likely to be maintained than biotech. It appears that this subgroup may have been driving the earlier results.

Table 5: Regression results by technology subcategories

Industry Sub-category	B	Standard Error	Significance p
Agriculture, Food & Textiles – Chemical	-0.349	0.089	<.0001
Coating Chemicals	0.044	0.077	0.570
Gas Chemical	0.023	0.111	0.833
Organic Compounds- Chemical	-0.131	0.069	0.058
Resins – Chemical	-0.091	0.068	0.180
Miscellaneous- Chemical	0.013	0.063	0.834
Communications- CnC	0.185	0.067	0.006
Computer Hardware & Software – CnC	0.146	0.070	0.036
Computer Peripherals- CnC	0.263	0.094	0.005
Information Storage-CnC	0.280	0.076	0.000
Drugs- DnM	-0.210	0.067	0.002
Surgical Instruments- DnM	0.069	0.070	0.325
Miscellaneous Drugs & medical – DnM	0.191	0.092	0.038
Electrical devices-EnE	0.216	0.070	0.002
Electrical Lighting-EnE	0.015	0.075	0.840
Electrical Testing-EnE	-0.026	0.070	0.712
Nuclear & X-ray – EnE	0.093	0.074	0.211
Power Systems- EnE	0.028	0.070	0.691
Semiconductors – EnE	0.309	0.072	<.0001
Miscellaneous EnE	0.246	0.073	0.001
Material Handling – Mechanical	-0.023	0.066	0.730
Metal working – Mechanical	0.048	0.070	0.487
Motors & Engines + parts – Mechanical	0.113	0.068	0.098
Optics- Mechanical	0.302	0.072	<.0001
Transportation- Mechanical	-0.197	0.069	0.004
Miscellaneous Mechanical	-0.048	0.066	0.473
Agriculture, Husbandry, Food –Other	-0.029	0.073	0.693
Amusement devices –Other	-0.282	0.083	0.001
Apparel & Textile – Other	-0.214	0.076	0.005

Earthworking & wells- Other	-0.109	0.080	0.170
Furniture, House Fixtures – Other	-0.216	0.073	0.003
Heating –Other	0.020	0.083	0.813
Pipes & Joints –Other	0.115	0.090	0.203
Receptacles- Other	-0.184	0.073	0.012
Miscellaneous –Other	-0.027	0.064	0.675

These technology specific results tell an interesting story. The hierarchy of technology in terms of the likelihood of renewal is as follows:

		Semiconductors—electrical (0.309)
		optics-mechanical (0.302)
More		information storage—CnC (0.280)
		computer peripherals—CnC (0.263)
Likely to	↑	miscellaneous electrical—electrical (0.246)
Be		electrical devices – electrical (0.216)
		communications—CnC (0.185)
		computer hardware and software—CnC (0.146)
		biotech (and all others not specifically listed)
Maintained		receptacles-other (-0.184)
		transportation-mechanical (-0.197)
		drugs—DnM (-0.210)
		apparel and textile—other (-0.214)
		furniture and house fixtures—other (-0.216)
		amusement devices—other (-0.282)
		agricultural, food & textiles—Chem (-0.349)

First, we must acknowledge that this study in measuring the likelihood that a patent will be maintained, is not truly measuring patent value as much as it is measuring long term patent value or delayed patent value. The fact that patents on computer-related inventions are more likely to be maintained than those on biotech is surprising. Our intuition suggested that in fast moving technologies, such as computer software or hardware, few patents would likely continue to be valuable twelve years into their patent term because the technology would have likely changed so drastically. That is not to say that these patents were not extremely valuable patents for the first three years of their life. In fact, they may have generated more revenue or protected more market share for their

owner in those three years than a new drug patent which often spends its first few years bogged down in the FDA approval process. Hence, when the technology is of the type that makes the patent value front-end loaded, we thought that these patents would appear not to be as valuable as patents where the patent value is backend loaded in our model. In actuality, the model demonstrates that computer software and hardware patents were significantly more likely to be maintained than biotech or pharmaceutical patents, indicating that the hardware and software patents filed in 1991 had a longer valuable life for their owners than did the biotech patents.⁶⁹

It may have to do with the underlying patenting patterns of the industry and in particular the rush to patent before sufficient product and market research is done to ascertain the commercial viability of the resultant product. A software or hardware patent is generally not filed until a tangible product exists—either a program is written or hardware is designed. Hence, these sorts of patents are generally filed later in the developmental stage. Biotech, pharmaceutical and chemical compound patents, in contrast, are generally filed earlier in the research stage where end results or uses are still uncertain.⁷⁰ Hence, in the biotech or pharmaceutical area there is a higher variance in patent value.

⁶⁹ The dataset of patents issued in 1991 likely does not have a large number of software patents because in general, the Federal Circuit's decision in *In re Alappat*, 33 F.3d 1526 (1994) is generally recognized as opening the PTO doors to software patentability. See, e.g., Gregory J. Maier & Robert C. Mattson, *State Street Bank in the Context of the Software Patent Saga*, 8 GEO. MASON L. REV. 307, 326 (1999).

⁷⁰ Recognizing that thousands of gene patents and gene fragment patents were being filed prior to the discovery of any specific, legitimate utility, the PTO promulgated stricter utility guidelines for examination of these applications. Cf. Burk & Lemley, *supra* note 3, at 1645-46 (explaining the utility guidelines raises the utility standard for the life sciences to ensure that patent protection is not sought too early in the developmental process—"before the actual use of the product has been identified"); Julian David Forman, *A Timing Perspective on the Utility Requirement in Biotechnology Patent Applications*, 12 ALB. L.J. SCI. & TECH. 647, 679-81 (2002) (arguing that the Utility Guidelines promulgated in 2001 force gene patents too far downstream); .

This model with its finer technical classifications and resultant technical variation indicates that the other identified characteristics (claims, cites received, etc), continue to indicate value regardless of technology type. Hence, while this concern about technology type and when a patent's value is fully realized leaves open a question about whether this study measures value when it looks at maintenance, the results regarding the other characteristics are not similarly impacted. For example, there is no reason to think that patents with fewer claims are likely to be more valuable in three years of patent life than patents with more claims are in twenty. There are no major cost recovery differences (such as R&D) which impact the number of claims in a patent application the way they impact technology categories.

The findings that patents in some industries and technologies are valuable longer than patents in others have significant implications for study of the patent system. One example of how these industry-specific empirical findings on renewal rates inform patent study concerns our findings regarding semiconductor patents. Two major studies of the semiconductor industry reported in 1983 and 1990 (the Yale and Carnegie Mellon studies) each reported that patents were among the least effective mechanisms for appropriating returns from research and development expenditures.⁷¹ It was suggested that the rapid pace of technological change and short product life cycles caused the semiconductor industry to rely more on trade secrets, lead time and manufacturing capabilities to protect their technological advances rather than patents.⁷² Contrasting the

⁷¹ Richard C. Levin, et.al, *Appropriating the Returns from Industrial Research and Development*, 3 BROOKINGS PAPER ON ECON. ACTIVITY 783, 785-86 (1987); Wesley Cohen, et.al, *Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Forms Patent (or Not)*, NAT'L BUREAU OF ECON. RES., Working Paper No. 7552 (2000).

⁷² Bronwyn H. Hall & Rosemarie Ham Ziedonis, *The Patent Paradox Revisited: An Empirical Study of Patenting in the U.S. Semiconductor Industry, 1979-1995*, 32 RAND J. ECON. 101, 102 (2001).

survey evidence which suggested that semiconductor firms do not rely heavily on patents to protect inventions with the rise in semiconductor patenting rates created what some described as a “patenting paradox.”⁷³ A study by Hall and Ziedonis, found that among capital-intensive firms in the semiconductor industry, patenting seemed to be largely viewed as a defensive strategy – a “patent portfolio race.”⁷⁴ Our finding that patents on semiconductor inventions are the most likely to be renewed of all the different industries certainly undermines the claims of others that the semiconductor industry does not value patent rights.⁷⁵

III. Getting a Clearer Sense of Value: Comparing Patents Which Expired for Failure to Pay Maintenance Fees with Litigated Patents

Comparing and contrasting the data on worthless patents with our previous work on litigated patents may help clarify the significance of patent characteristics for patent valuation. Table 6 lists the data from this study on expired and unexpired patents (from those that issued in 1991) and data on patents that issued from 1976-1999 (2,224,379 patents) and patents that were involved in litigation that terminated during the two-year period 1999-2000 (6,861 patents).⁷⁶ The litigated patents data are not a dataset of all patents that issued in 1991 and that were litigated. If it were possible to identify all of the patents that issued in 1991 and were involved in litigation during their life, the

⁷³ *Id.*

⁷⁴ *Id.* at 125.

⁷⁵ See *supra* notes 69-70 and accompanying text. Our finding in the litigation-based study that despite the high rate of semiconductor patenting, there was a low rate of semiconductor litigation further substantiated the claim that the semiconductor industry, more so than other technologies, uses patents defensively to ensure cross licensing and avoid hold-ups. See *Valuable Patents*, *supra* note 15.

⁷⁶ For a discussion of the issued patents data and the litigated patents data, see *Valuable Patents*, *supra* note 15.

comparison would be more appropriate with the data on expired and unexpired patents in this study. The closest comparison we can make at this time is with the database of litigated patents from 1999-2000. Because patent characteristics have changed over time,⁷⁷ a straight-forward comparison of patent litigated in 1999-2000 (which issued in many different years) with issued patents from 1991 is not appropriate. To control for these changes, the issued patents database is weighted in proportion to the patents that were litigated. For example, if 10% of the litigated patents were issued in 1999, this study gives issued patents from that year 10% of the weight.

Table 6: Comparing Worthless and Valuable Patents				
Characteristic	Worthless Patent (Expired 4, 8, 12)	Issued Patents (Unexpired Patent -- 1991)	Issued Patents (1976- 1999)	Valuable Patents (Litigated Patent)
Claims	12.0 (11.5, 12.0, 12.7)	13.3	13.0	19.6
Cites Made	7.51 (7.39, 7.55, 7.53)	7.78	8.43	14.20
Cites Received	4.72 (4.16, 4.77, 5.79)	7.40	4.32	12.23
Related Apps	0.30 (0.27, 0.30, 0.34)	0.38	0.40	1.04
Prosecution Time (Yrs.)	2.14 (2.10, 2.13, 2.20)	2.32	2.47	3.75
Inventors	1.96 (1.81, 1.99, 2.07)	2.16	2.10	1.86
Percent Foreign	0.47 (0.44, 0.47, 0.50)	0.48	0.46	0.17

As Table 6 indicates, the characteristics that identified patents that were more likely to be renewed (patents of more value) also identify patents that are likely to be litigated (patents of more value).⁷⁸ Expired patents had fewer claims than unexpired

⁷⁷ Hall et al., *supra* note 42, at (finding that patent citation and claiming practice has changed over time).

⁷⁸ Given the high litigation costs, litigated patents are, at a minimum, a subset of all valuable patents. As discussed, there can be a number of ways in which patents may be valuable to their owners such as signaling, licensing, or defensively. Many such valuable patent may never be litigated and these valuable, unlitigated patents may not share the same characteristics as the litigated ones. For a discussion of the litigation/value relationship, see *Valuable Patents*, *supra* note 15.

patents which had fewer claims than litigated patents. Fewer U.S. prior art cites were considered during the examination of expired patents than during the examination of unexpired patents and fewer cites were considered during the prosecution of unexpired patents than were considered during the prosecution of patents that were ultimately litigated. The same is true for citations received, time spent in prosecution at the PTO and the number of related applications that were filed by the patentee. Each of these characteristics is significant in identifying the likelihood that a patent will expire and the likelihood that a patent will be litigated. This supports the claim that these characteristics are indicia of patent value.

The number of inventors and the percentage of the inventorship entity that is foreign do not, however, do not consistently signify value in the two metrics. A higher number of inventors indicates that a patent is more likely to be maintained (not expire), but the lower the number of inventors, the more likely a patent is to be litigated. Similarly, the greater the percentage of the inventorship that is foreign, the more likely a patent is to be maintained, however, the lower the percentage of foreign inventorship, the more likely a patent is to be litigated.

Does that mean that these characteristics are not indicative of patent value? Probably not. The likely explanation is that certain kinds of patentees are more litigious than others. In an earlier work, *Xenophobia in American Courts*, the author discovered that foreign parties acquire 45% of all U.S. patents annually, but only initiate 13% of U.S. patent litigation to enforce those patents.⁷⁹ Similarly, in an on-going study, the author has found that individuals, who acquire a small percentage of all issued patents, are much

⁷⁹ Moore, *Xenophobia*, *supra* note 7, at 1504.

more likely than corporations to litigate to enforce those patents.⁸⁰ Characteristics of the person or patentee (such as foreign or domestic and individual or corporation), rather than of the patent (such as claims, prior art cites, etc), may still be good predictors of patent value despite their inability to predict litigation. Litigation is not the only form of patent value and foreign and corporate patentees would be more likely to acquire patents for defensive or signaling purposes than domestic individuals.

Finally, with regard to technology, both the litigated patents comparison and the renewal data comparison reach surprising conclusions. In the broad technology classifications, computers and communication patents are more likely to be maintained and more likely to be litigated than all of the other types of patents. Mechanical patents fall into the middle in both maintenance and litigation rates. The rest of the technology classifications, however, reach results which seem inconsistent: electrical and electronic patents are likely to be maintained, but unlikely to be litigated, whereas chemical, drugs and medical and other patents are more likely to be litigated and less likely to be maintained. These results, while seemingly inconsistent, actually tell a logical story. In the computer and communication technology, patenting decisions are made late in the developmental process, when software is written or hardware is designed. Accordingly, it makes sense that patenting in these industries is more predictive of commercial value. Patenting in the biotech, pharmaceutical or chemical industries, generally occurs at earlier stages of product development. Therefore, these patents are closer to a lottery. However, given the high research and development costs in these industries as opposed to

⁸⁰ Moore, *Populism and Patents*, *supra* note 57.

mechanical or electrical, the patents that do result in commercial products are very important to the patentee's ability to recoup costs which explains the high litigation rates.

A comparison of the finer technical classifications supports this theory as well.⁸¹ Some categories such as optics, communications or electronics have both a high litigation rate and a high maintenance rate. Others seem contradictory but seem to follow the same pattern where a combination of stage of development and research and development costs impacts maintenance and litigation rates in seemingly opposite ways.

An alternative possible explanation for why some industries may have high rates of renewal, but low rates of litigation is that industries not only value patents differently in terms of their ability to protect intellectual assets and recoup R&D expenditures, but that among industries that value patents, they value them for different reasons.⁸² Some industries and some firms value patents for their ability to generate revenue (licensing and litigation) while others value them more for defensive purposes (cross licensing or avoiding holdups). Renewal fees confirm the continued value of the patents acquired whereas litigation data confirms the specific value as revenue generation.

Industry variation in litigation rates and renewal rates has significant implications for the study of the patent system, patent policy and patent value. As between the two, renewal rate seem a better predictor of value than litigation rate as renewal rate would capture data on the many ways a patent may be of private value. Litigation rate data would never identify patents whose value stems from their defensive use as part of a

⁸¹ A direct comparison of the finer technology classifications is not entirely straightforward since the classifications herein are based on the PTO classification system and the finer classifications in the Valuable Patents paper were done by hand on a sample. *See Valuable Patents, supra* note 15.

⁸² This explanation is consistent with the economic literature which concludes that patents play different roles in different industries. *See supra* note 62.

large portfolio or their use as a signal to consumers, competitors or venture capitalists. Finally, there are of course, valuable patents that generate significant licensing revenue which are never litigated. Since litigated patents are only a subset of valuable patents and may not be a representative subset, renewal data seems a more objective measure of value. Moreover, renewal data eliminates much of the personal idiosyncrasies that appear in litigation data such as litigation aversion by foreign parties or the different patenting strategies of individuals and corporations which may make litigation rate data less reliable as a measure of the patent's value. While renewal rate data may be better at identifying a large number of privately valuable patents, litigation data is certainly useful for identifying the characteristics of the patents, the technology, and the patent owners which are likely to get litigated. In addition to differences in qualitative value that comes from litigation and renewal rate data, there is a difference in quantitative value which must be acknowledged. Renewal rate data identifies patents whose value to their owner is at least the cost of the maintenance fees (\$910-\$6200)⁸³ whereas litigation rate data identifies patents whose value is generally much higher quantitatively and may span a large range. For example, a patent for which litigation is initiated may be valued based on the cost the owner is willing to pay for the litigation – the litigation costs and attorneys fees. Obviously the further the litigation progresses the more money the litigation costs and the more valuable the patent must be to its owner.⁸⁴ Hence renewal fee data is useful for analysis of a broader range of valuable patents because it captures all kinds of value

⁸³ See *supra* note 33 and accompanying text.

⁸⁴ See generally AMERICAN INTELLECTUAL PROPERTY LAW ASSOCIATION, REPORT OF THE ECONOMIC SURVEY 2003, at 93-94 (2003) (demonstrating that the median litigation expenses for a patent infringement vary depending on the location and the stage that the case progresses too).

but litigation data is useful for analysis of a subset of the most valuable patents. Finally, since the litigation rate data and the renewal rate data are identical on which characteristics of the patents are likely to be indicia of a patents value, they both provide useful information for patent valuation.

Conclusion

This article provides empirical estimates of the importance of the patent system as a source of economic return on inventive activity. Literature on intellectual property rights and patent policy questions whether the patent system is an effective incentive mechanism for spurring innovation and disclosure; in fact, some question the very existence of a patent system.⁸⁵ Others question whether the importance of the patent system varies across technology areas and have suggested that patent laws might be tailored to particular technology areas.⁸⁶ Since patenting is just one of several alternative

⁸⁵ Fritz Machlup, *An Economic Review of the Patent System*, Subcommittee on Patents, Trademarks, and Copyrights of the Senate Committee on the Judiciary, 85th Cong., 44-45 (Comm. Print 1958) (summarizing arguments for and against the patent system); EDITH PENROSE, *THE ECONOMICS OF THE INTERNATIONAL PATENT SYSTEM* (1951) (arguing that patent systems harm developing countries); C. TAYLOR & Z. SILBERSTON, *THE ECONOMIC IMPACT OF THE PATENT SYSTEM: A STUDY OF THE BRITISH EXPERIENCE 194-208* (1973) (reporting results of a survey suggesting that abolition of the patent system would affect innovation in some industries more than in others). *But see* Brian Peckham, *Should the U.S. Patent Laws Be Abolished?*, 11 J. CONTEMP. L. 389, 421 (1985) (concluding that present knowledge does not strongly justify immediate abolishment of the patent system).

⁸⁶ *See* James Bessen & Eric Maskin, *Sequential Innovation, Patents, and Imitation*, Mass. Inst. of Tech. Working Paper No. 11/99, (1999) (arguing that patent protection is altogether unnecessary in some industries even though it may be necessary in others). Computer software and databases have been popular targets for sui generis legislative proposals. *See, e.g.,* Peter S. Menell, *Tailoring Legal Protection for Computer Software*, 39 STAN. L. REV. 1329 (1987) (arguing for sui generis protection); J.H. Reichman & Pamela Samuelson, *Intellectual Property Rights in Data?*, 50 VAND. L. REV. 51, 64-76 (1997) (discussing the rationale for sui generis database legislation); Pamela Samuelson, et al., *A Manifesto Concerning the Legal Protection of Computer Programs*, 94 COLUM. L. REV. 2308 (1994) (discussing a sui generis regime for protecting computer software); Jane C. Ginsburg, *Copyright, Common Law, and Sui Generis Protection of Databases in the United States and Abroad*, 66 U. CIN. L. REV. 151, 171-76 (1997) (arguing for a new sui generis form of intellectual property protection for databases); Himanshu S. Amin, *The Lack of Protection Afforded Software Under the Current Intellectual Property Laws*, 43 CLEV. ST. L. REV. 19 (1995) (suggesting sui generis intellectual property protection for software to balance the interests of software developers with those of society). Biotechnology is another technology which has attracted sui generis proposals. *See, e.g.,* Dan L. Burk, *Copyrightability of Recombinant DNA Sequences*, 29 JURIMETRICS J. 469 (1989) (arguing that copyright-like protection would be more appropriate for protection

forms of protection that might be sought for innovative output, the decision to patent depends on the comparative efficacy of this intellectual property rights scheme and in particular on the difference in returns that would accrue to the invention with and without patent protection. The patentee's estimate of this incremental value determines both whether patent applications are filed and whether patents are renewed. The empirical study presented in this article provides information on the value of the protection generated by the patent laws and how that value may vary.

While many scholars have attempted to use patent counts to measure innovative output,⁸⁷ as the high percentage of patent expirations found in this study shows, patents vary greatly in their private and social value. Whether a patent is likely to be maintained by its owner is indicative of the long term value of the patent. Whether a patent is likely to end up in litigation is indicative of the value of the patent to not only its owner, but to competitors as well since they are accused of infringement. But litigation rate data are limited to identifying patents which are valuable to their owners purely as revenue generation means and ignores other forms of private value that may exist for patents (defensive or signaling value). The fact that the patent characteristics do predict

of biotechnology); S. Benjamin Pleune, *Trouble With the Guidelines: On Urging the PTO to Properly Evolve with Novel Technologies*, 2001 J.L. TECH. & POL'Y 365 (arguing for DNA-specific legislation). In fact, both existing statutes and precedent single out biotechnology for different application of various patent laws. See 35 U.S.C. § 103(b); Burk & Lemley, *supra* note 3, at 1577. Semiconductor chips and plants have, in fact, received *sui generis* legislative protection. 17 U.S.C. §§ 901-914 (semiconductor chip rights); 35 U.S.C. § 161-64 (plant patent rights); 7 U.S.C. § 2401 (plant variety protection act rights). See also Mark D. Janis & Jay P. Kesan, *U.S. Plant Variety Protection: Sound and Fury?*, 39 HOUS. L. REV. 727, 730-45 (2002) (discussing the emergence of *sui generis* systems for plant variety protection).

⁸⁷ See Lanjouw, et al., *supra* note 36, at 406 (lamenting the use of patent counts as a flawed measure of innovative output); Ariel Pakes & Margaret Simpson, *Patent Renewal Data*, BROOKINGS PAPERS: MICROECONOMICS 331, 363-65 (1989) (explaining the problems with using patent counts as a measure of inventive activity).

likelihood of patent maintenance and the likelihood of patent litigation suggests that they are useful predictors of value.

While this article has found patent maintenance fee data useful for identifying *ex ante* valuable patents and therefore helps to debunk this black art, patent maintenance fee data is at present an underutilized tool in assessing intellectual property rights policy. The high rate of patent expiration suggests that maintenance fees are useful as an innovation sorting mechanism. The data show that patentees are better at identifying the innovative value of technology as quickly as three and a half years after a patent issues than they are before, likely because of uncertainty in technological advancement. There is no way of knowing with great precision the twists and turns technology will take after an advance is disclosed. It may be that an industry widely embraces a given technology which results in a huge return for the patentee or perhaps competitors successfully generate design alternative. The data permit some generalities. For example, patentees obviously rush to patent before meaningful estimates of the expected return of any given technology is ascertained. The identification of this rush to patenting in the present U.S. patent system is important. If the rush is substantial in our present first-to-file patent acquisition system, it would likely be exacerbated if the U.S. patent system were to move to the first-to-file system of every other country, a major reform proposal under nearly constant consideration. A further implication of these data, and the identified patent rush, is that the current system of patent examination by the PTO, which is heavily criticized, may in fact be optimal. It would be inefficient for the PTO to spend more time evaluating worthless applications.⁸⁸

⁸⁸ See Lemley, *Rational Ignorance*, *supra* note 16 (suggesting that it would be inefficient for the PTO to spend more time on patent applications).

Finally, little thought seems to have been put into the current schedule of patent maintenance fees. It may be possible to redesign the PTO maintenance fee schedule more strategically to increase social welfare.⁸⁹ Since renewal fees and the payment thereof effectively determine patent term, the renewal fee schedule could differ by technology. An annual renewal fee, like those found in most countries, may have advantages over the current four year fee schedule or alternative fee schedules which vary based on the term of the patent could be created. Annual renewal fee schedules would likely result in technology entering the public domain sooner. It seems unlikely to impact disclosure or patent filings given the high cost of patent application as compared to the low cost of maintenance fees, but would likely result in more technology entering the public domain sooner. It may also be the case that maintenance fee schedules ought to be inverted; namely higher maintenance fees on the front end and lower over time. Maintenance fee data is an area ripe for additional research. This study has found one use for maintenance fee data, namely identifying the characteristics of valuable patents, which is useful in patent valuation theory as well as for targeting reforms to the Patent and Trademark Office, there are undoubtedly others.

⁸⁹ See Francesca Cornelli & Mark Shankerman, *Optimal Patent Renewals*, (working paper on file with author) (finding that revising that patent renewal fee schedule for high R&D productivity firms to one where renewal fees rise more sharply with patent term length would yield significant welfare gains).