WORTHLESS PATENTS

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Each year the United States Patent and Trademark Office (PTO) receives 350,000 patent applications[1] and grants approximately 180,000 patents.[2] Despite the large number of patent grants annually, patent holders

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1. Patent filings have risen dramatically in recent years. *See* PTO, U.S. PATENT STATISTICS, CALENDAR YEARS 1963-2004, http://www.uspto.gov/web/offices/ac/ido/oeip/taf/us_stat.pdf (Aug. 2005) (demonstrating that the number of patent applications filed in the U.S. has nearly doubled in the last ten years).

2. 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, the agency could hire and retain even more examiners to ensure that only quality patents are is-

file only 3,000 patent lawsuits involving approximately 4,500 patents each year to enforce patents against infringers. What happens to the other 175,500 patents granted each year? Are unlitigated patents valuable or is the patent system a very expensive lottery?[3]

Litigated patents are not the only valuable patents: unlitigated patents may be valuable as defensive measures,[4] as deterrents to block others,[5] to

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sued."). Alternatively, perhaps the lower grant rate reflects a PTO which has become more selective (stricter) in applying patent requirements.

3. "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* JOHN JEWKES ET AL., THE SOURCES OF INVENTION 253 (1st ed. 1958) (finding the patent system is wasteful and lacking 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 BOUNDARIES OF INTELLECTUAL PROPERTY: INNOVATION POLICY FOR THE KNOWLEDGE SOCIETY (Rochelle Cooper Dreyfuss et al. eds., 2001); A. Samuel Oddi, *The Tragicomedy of the Public Domain in Intellectual Property Law*, 25 HASTINGS COMM. & ENT. L.J. 1, 39 (2002) (analogizing the race to patent to a lottery); *cf.* Allan N. Littman, *Restoring the Balance of Our Patent System*, 37 IDEA 545, 564 (1997) (analogizing patent litigation to a lottery system).

4. *See, e.g.*, John H. Barton, *Reforming the Patent System*, 287 SCI. 1933 (2000) (discussing 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."); Kimberly A. Moore, *Xenophobia in American Courts*, 97 NW. U. L. REV. 1497, 1532-33 (2003) (discussing defensive use of patents); 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."); Jean O. Lanjouw & Mark Schankerman, An Empirical Analysis of the Enforcement of Patent Rights in the United States (Feb. 4, 2002) (working paper), http://www.nber.org/confer/2002/prods02/lanjouw.pdf ("Patentees with a large portfolio of patents to trade . . . . more successfully avoid court actions.").

5. Blocking patents typically involve a pioneer or improver who refuses mutually beneficial development and cross-licensing. *See* John H. Barton, *Antitrust Treatment of Oligopolies with Mutually Blocking Patent Portfolios*, 69 ANTITRUST 851 (2002) (discussing blocking patents); 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"); 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 Equiva-*

create a patent thicket,[6] for signaling purposes,[7] or to generate revenue solely through licensing.[8] Patent value may be an illusive concept because of the many differing ways that a patent can be valuable and the impossi-

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lents 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).

6. Companies often seek patents 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 overlap among patents which results in multiple parties being able to lay claim to the same invention. James Bessen, Patent Thickets: Strategic Patenting of Complex Technologies (Mar. 2003) (working paper), http://www.researchoninnovation.org/thicket.pdf (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).

7. ADAM B. JAFFE & JOSHUA LERNER, INNOVATION AND ITS DISCONTENTS 16 (2005) ("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."); 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"); Clarissa 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). 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. Research, Working Paper No. W6846, 1998), http://papers.nber.org/papers/w6846 ("We find that the amount of venture capital activity in an industry significantly increases its rate of patenting.").

8. 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." Oren Bar-Gill & Gideon Parchomovsky, *The Value of Giving Away Secrets*, 89 VA. L. REV. 1857, 1867 (2003). 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 it appears that this patent was never litigated. *See id.* at 1871. 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 7, at 57 (suggesting 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 1980s).

bility of obtaining sufficient empirical data on each.[9] Patent worthlessness, however, may be more easily quantified, which I endeavor to do in this Article.

Despite the high cost of patent acquisition,[10] there are a significant number of patents issued each year that are criticized for their absurdity.[11] There are websites[12] and magazine columns[13] devoted to chronicling such patents. For example, issued U.S. patents have claimed an animal toy which includes a tree branch,[14] a face mask to prevent a person from eating,[15] a bird diaper,[16] an apparatus for simulating a "high five,"[17] an air

9. Obtaining a database of litigated patents in any given time period is possible, and in fact, I did just this for the 6,861 patents that were involved in litigation that terminated between 1999 and 2000. *See* John R. Allison et al., *Valuable Patents*, 92 GEO. L.J. 435 (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.

10. Preparation and prosecution of a patent application by a patent attorney costs anywhere from $5,000 for a simple invention to hundreds of thousands of dollars for complex inventions. *See* John R. Thomas, *Collusion and Collective Action in the Patent System: A Proposal for Patent Bounties*, 2001 U. ILL. L. REV. 305, 345 (2001) (stating that attorneys charge several thousand dollars to prepare simple patent applications and considerably more for complex applications or applications involved in appeals or interferences); *cf.* Mark A. Lemley, *Reconceiving Patents in the Age of Venture Capital*, 4 J. SMALL & EMERGING BUS. L. 137, 138 (2000) ("[I]n the United States alone, the prosecution costs—what we're paying patent prosecutors and the PTO—exceed $5 billion a year."). The fees to the PTO are a small portion of the overall cost. The PTO currently charges applicants $1,000 to file a patent application and $1,400 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, nonprofit corporation, or corporation which qualifies as a small business under the Small Business Act. *Id.*

11. *See* James Gleick, *Patently Absurd*, N.Y. TIMES, Mar. 12, 2000, Magazine, *available at* http://www.around.com/patent.html; Lawrence Lessig, *The Problem With Patents*, INDUS. STANDARD, Apr. 23, 1999, *available at* http://www.thestandard.com/article/0,1902,4296,00.html.

12. *See, e.g.*, Bizarre Patents, http://www.patex.ca/bizarre_patents.html (last visited Nov. 23, 2005); Crazy Patents, http://www.crazypatents.com (last visited Nov. 23, 2005); Delphion's Gallery of Obscure Patents, http://www.delphion.com/gallery (last visited Nov. 23, 2005); Totally Absurd Inventions, http://totallyabsurd.com/absurd.htm (last visited Nov. 23, 2005).

13. For example, there is a column in Scientific American entitled *You Can Patent That?* which discusses patents issued each month that according to the author "transcend the mundane." Gary Stix, *You Can Patent That?*, 289 SCIENTIFIC AM. 32 (2003).

14. U.S. Patent No. 6,360,693 (filed Dec. 2, 1999).

15. U.S. Patent No. 4,344,424 (filed Mar. 27, 1980).

16. U.S. Patent No. 5,934,226 (filed Oct. 15, 1997).

17. U.S. Patent No. 5,356,330 (filed Dec. 7, 1993).

conditioning unit for a shoe (to keep one's feet cool),[18] a method of swinging on a swing,[19] an electronic toilet queue,[20] a dust cover for a dog,[21] 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.[22] At least the Federal Circuit recently affirmed the PTO's denial of patent claims to a crustless-peanut-butter-and-jelly sandwich.[23] 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 identify worthless patents. After a patent issues, the fees to the PTO do not end. The patentee must pay maintenance fees at three intervals during the life of a patent.[24] 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 $2,300 or the patent will expire at the eight year point, and eleven and a half years after issuance, the patentee must pay $3,800 or the patent will expire at the twelve year point.[25] Even though there is a uniform patent term for all patents (twenty years from the date of the application[26]), renewal fees create a de facto differentiation in

18. U.S. Patent No. 5,375,430 (filed Oct. 5, 1993).

19. U.S. Patent No. 6,368,227 (filed Nov. 17, 2000).

20. U.S. Patent No. 6,329,919 (filed Aug. 14, 2000). Even large corporations like IBM, which filed this patent, seek patents with marginal economic value and social utility.

21. U.S. Patent No. 3,150,641 (filed Sept. 4, 1963).

22. U.S. Patent No. 5,443,036 (filed Nov. 2, 1993).

23. 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 (filed Dec. 8, 1997).

24. 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-Funding Patent Offices*, 4 TOPICS IN THEORETICAL ECON. 2 (2004), *available at* http://www.bepress.com/bejte/topics/vol4/iss1/art6 ("Economists have found the rising fee structure to be a desirable feature of the patent renewal process.").

25. 37 C.F.R. §§ 1.20(e)-(g) (2004). The maintenance fees for small entities are halved. *Id.* If a patent expires due to nonpayment of maintenance fee, it can be "unexpired" if the patentee convinces the PTO that the late payment was either unavoidable or unintentional. *Id.* § 1.378.

26. 35 U.S.C. § 154(a)(2) (2000).

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 $900 maintenance fee. Nevertheless, this empirical study has found that 53.71% of all patentees do allow their patents to expire for failure to pay one of their maintenance fees.[27] Importantly, patents that expire for failure to pay maintenance fees share some common identifiable characteristics. No other empirical scholarship in the legal or economic literature has considered the characteristics of expired patents as a measure of the patents' innovative output.[28]

This Article provides a means of systematically identifying worthless patents.[29] The analysis here compliments my earlier work on identifying valuable patents,[30] 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 my recent study on litigated patents. 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. Renewal rate data is a better predictor of patent value than litigation data because it captures the many forms of private value that may be conferred by a patent: defensive, deterrent, signaling, and revenue generation.

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27. Patentees apparently understand the economic idea of sunk costs and are willing to cut their losses.

28. 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 24, at 15 (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 Patents and Value Intellectual Property: Uses of Patent Renewal and Application Data*, 46 J. INDUS. ECON. 405 (1998) (presenting a model using patent counts and renewal data as a measure of the extent of innovation).

29. I acknowledge that my definition of value in this paper corresponds to long term patent value. My definition necessarily assumes that the longer the patentee continues to maintain the patent the longer the patent is valuable and 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.

30. Allison, *Valuable Patents*, *supra* note 9.

I. THE EMPIRICAL STUDY

A. Data Collection

To quantify or qualify patent value, I collected an original dataset of all of the 96,713 utility patents issued by the PTO in 1991. Although 1991 seems 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.[31] Patents can expire for failure to pay maintenance fees four, eight, or twelve years after issuance.[32] Hence, looking at patents that issued in 1991 permits 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, I examined whether more recently issued patents shared the same characteristics at their four year points, and found my results replicated.

For each of the patents issued in 1991, I searched the weekly issues of the Patent Office Official Gazette for 1995, 1999, and 2003 to ascertain whether it expired due to the owner's failure to pay maintenance fees. I created a list of the 51,949 patents that did expire for failure to pay maintenance fees.[33] Table 1 below shows the breakdown of expired patents.

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31. 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 (1991). Patents filed after June 8, 1995, have a patent term of twenty years from their filing date. Uruguay Round Agreements Act, Pub. L. No. 103-465 (1994) (codified at 35 U.S.C. § 154(a)(2)). This amendment means a patent may not still be enforceable twelve years after issuance (if they were pending at the PTO for eight or more years). *Id.* Even if patents are enforceable at the twelve year point, if they have shorter remaining lifespans 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.

32. *See supra* note 25 and accompanying text.

33. 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. 37 C.F.R. § 1.378 (2004). To show unintentional delay, the patentee has to file a reinstatement petition within twenty-four months after the six month grace period. *Id.* For unavoidable delay, the patentee has to promptly file a petition after receiving notice or becoming aware of expiration of patent. *Id.* Hence for the 988 patents that were reinstated, I 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. I adjusted the data to properly account for each of the reported corrections.

I also collected detailed characteristic information on the patents, the inventors, and the assignees. In particular, I 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, including 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 technology classification system). This patent characteristic data was derived from the extensive empirical work of Bronwyn Hall, Adam Jaffe, and Manual Trajtenberg, and is available through the National Bureau of Economic Research.[34]

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, I compared the expired and unexpired patents across a large number of variables. In particular, I examined the following characteristics to determine whether they influenced 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), 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 was foreign (Percent Foreign Investors), and whether the patent was unassigned at the time of issuance (Unassigned) or if assigned, whether it was assigned to a U.S. Corporation, Foreign Corporation, U.S. Individual, Foreign Individual, U.S. Government, or Foreign Government. The data were also broken down into seven different fields of technology: Chemicals, Communications and Computers, Drugs and Medical, Electrical and Electronics, Mechanical, and Other. Recognizing

34. Bronwyn H. Hall et al., *The NBER Patent Citation Data File: Lessons, Insights and Methodological Tools* (Nat'l Bureau of Econ. Research, Working Paper No. 8498, 2001).

that there are shortcomings with such broad technology classifications, in a finer analysis I split technology classifications into thirty-six different technologies.[35]

I hypothesize that the inherent value of a patent is a function of certain observable characteristics.[36] To test my hypothesis, I present descriptive statistics on the various patent characteristics and comparisons of the means. However, since descriptive statistics do not account for the relationships among variables, I also formulated an ordered logit model which starts out by assuming that patent values are randomly distributed according to a normal 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.

My model then estimates three cutoff points[37] which divide the probability distribution into four regions such that patents with values less than the first cutoff point expire in four years, patents with values in between the first and second cutoff points expire in eight years, patents with values between the second and third cutoff points expire in twelve years, and patents with values greater than the third cutoff value are maintained to their full legal term of seventeen years.

To determine the relationship between patent characteristics and the value of the patent, I specified an ordered logit model. An ordered logit

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35. In addition to the problems inherent in broad technology classifications (for example, pharmaceutical and medical device patents are grouped together and may 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 classes. 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); *see also* John R. Allison & Mark A. Lemley, *The Growing Complexity of the U.S. Patent System*, 82 B.U. L. REV. 77, 92 (2002); 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).

36. In my earlier work on patent characteristics, I discussed the characteristics that economists have used to predict patent value: claims, citations made, citations received, generality, originality, and IPC classifications. Allison, *Valuable Patents*, *supra* note 9. I found that the first three characteristics were unambiguously strong predictors of patent litigations, while the others were not. *Id.* at 451. See *infra* Part III for a more detailed comparison of patent characteristics in the *Valuable Patents* study and this study.

37. The cutoff points roughly correspond to the cutoff values of the patent. Since value is unobserved, the estimates are simply ordinal transforms of the actual unobserved value of the patent.

model is used when the dependent variable is unobserved but has an inherent ranking.[38] The logit model applies here because patents that expired within four years are less valuable than patents that expired in eight years, which are in turn are less valuable than patents that expired in twelve years. The dependent variable (value) is given a coded value of 1 if the patentee pays all the maintenance fees at the intervals specified by the PTO and the patent therefore remains unexpired until its full legal term. The variable 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 coded value of 4 if the patent expired at the end of four years. The nonlinear estimation technique used allows for estimation of cutoff 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 nonpayment 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.[39] Also, 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 fewer inventors than patents that were maintained.

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38. *See* W.H. GREENE, ECONOMETRIC ANALYSIS 926-28 (3d ed. 1997).
39. I refer to patents that were maintained to the full legal term as unexpired patents.

- Expired patents had fewer related applications than unexpired patents. Patents that expired earlier had fewer related applications than patents that expired later.

Table 1: Patent characteristics by category

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%
Number of Claims	13.27	12.63	11.95	11.44	12.01
Percent Foreign Inventors	0.47	0.51	0.47	0.44	0.47
Number of Citations Made	7.79	7.52	7.54	7.39	7.49
Number of Citations Received	7.13	5.49	4.67	4.03	4.73
Number of Inventors	2.14	2.07	1.99	1.82	1.96
Number of Related Applications	0.38	0.33	0.29	0.27	0.30
Application Time (years)	1.75	1.69	1.69	1.71	1.70
Total Prosecution Time (years)	2.32	2.18	2.13	2.10	2.14

1. Characteristics of the Patent

The correlation between early patent expiration and lower number of claims, lower number of prior art references, lower number of related applications, and shorter prosecution time conforms to my intuition. Patents with more claims are more expensive to file and prosecute.[40] These patents would also be more intimidating to potential infringers as more claims may mean more chances that they infringe the patent[41] and the harder the

40. The patent application fee covers a total of twenty claims (three of which may be independent). An applicant who wishes to file more than twenty claims or more than three independent claims must pay an additional fee per claim. 37 C.F.R. §§ 1.16(h)-(i). Of course, the application fee is small compared to the expense of having an attorney draft and prosecute the claims. *See supra* note 10 and accompanying text.

41. Because claim construction is an amorphous concept with high reversal rates on appeal to the Federal Circuit, patent applicants have responded to the high reversal rate by finding multiple ways to claim the same invention. This practice makes it more likely

patent will be to invalidate.[42] Hence, patents with more claims are generally more valuable.

Patents that cite more U.S. patent prior art during prosecution are likely more expensive for the patentee to prosecute. A patent cites prior art if it is either found by the examiner during the examiner's own search or disclosed to the examiner by the inventor. In theory, the more prior art a patent cites, the more extensively the examiner reviewed the patent application, and thus the more difficult it would be to invalidate the patent.[43] The data support the notion that patents with more prior art are more valuable.[44]

The higher the number of related applications the more expensive the invention was for the inventor to protect. Additional application fees and prosecution expenses come with each new application, continuation, continuation-in-part, or divisional application.[45] I 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 that the same inventor may have filed sepa-

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that a 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, 1, 11-12 (2001) (finding that the Federal Circuit reversed 33% of district court claims constructions on appeal). More claims means more bites at the apple for the patentee. Of course, a patent with five claims is not necessarily broader than a patent with one claim. *See* Moore, *Xenophobia in American Courts*, *supra* note 4, at 1543-44.

42. 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. The narrower the claim, the harder it will be to find prior art that discloses all of the same claim limitations. Second, even if the additional claims are not narrower, they will have a different scope and use different claim language, again making invalidation more difficult.

43. There is a presumption of validity for issued patents. 35 U.S.C. § 282 (2004). Judges and juries are reluctant to second guess the expert examiners at the PTO, and the more prior art the patent cites, the greater the reluctance.

44. The citation of a large number of U.S. patent prior art references means that the invention is likely not a pioneering invention, but rather an improvement in a crowded field. 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 for 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.

45. A request for continuing examination is like filing a new application and incurs another $770 fee. *See* 37 C.F.R. §§ 1.114, 1.17(e).

rately on the same or similar technology would not count.[46] Additionally, future applications that may rely on this patent for priority are likewise excluded. Consistent with my intuition, the larger the number of applications that the inventor already filed on the invention, the more likely the patent owner will be to pay their maintenance fees because the patent owner is more invested in the technology and its protection. A patent with many related applications may show the inventor's determination to patent the invention or show 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.[47]

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 before issuance. 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.[48] 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 correlation between application time (time from filing to issuance) and patent expiration. This result 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.

Although the value of patents correlates to both the number of claims and the quantity of citations to prior art, causation is not clear. More claims and more prior art citations may cause a patent to be more valuable.

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46. A patent portfolio race or a patent family is more than just a chain of applications. They generally include several chains that are not directly related, but are based on similar technologies. Future research needs to be done to develop a technique for identifying patent families. Such identification of patent families would improve the accuracy of the measure.

47. Large entities generally pay maintenance fees on portfolios of patents that are valuable as a portfolio even though patents in the portfolio may not be valuable individually. Studying both the number of related applications and the characteristics of the assignee mitigates this problem somewhat.

48. The relationship between the number of related applications and prosecution time is not necessarily linear. For example, 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 (filed June 5, 1995) actually did claim 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.

Conversely, a patentee may file more claims and cite more prior art when an invention and its protection are more important to the patentee.

Regardless of causation, however, differences exist between the kinds of patents that are likely to expire early and those that will be maintained. Many of the factors that 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 to continue prosecution. Each of these decisions affects the cost of the prosecution to the patentee.

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

2. Characteristics of the Inventor and/or Patentee

The larger the number of inventors, the more likely they are to maintain their patent. This result 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 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 the government. This may reflect the differing purposes for which corporations and individuals patent. For example, corporations 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.[49] It may also be the case that individuals are more attune to cost control than corporations. In corporations, there may be a disconnect between those paying the maintenance fees (in-house attorneys) and those evaluating the innovation value of particular patents. 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

	Unexp. Patents	Patents expired in 12 yrs.	Patents expired in 8 yrs.	Patents expired in 4 yrs.	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	25.4%	13.6%	43.0%	18.1%	74.6%
Foreign Government	37.7%	15.9%	29.0%	17.4%	62.3%

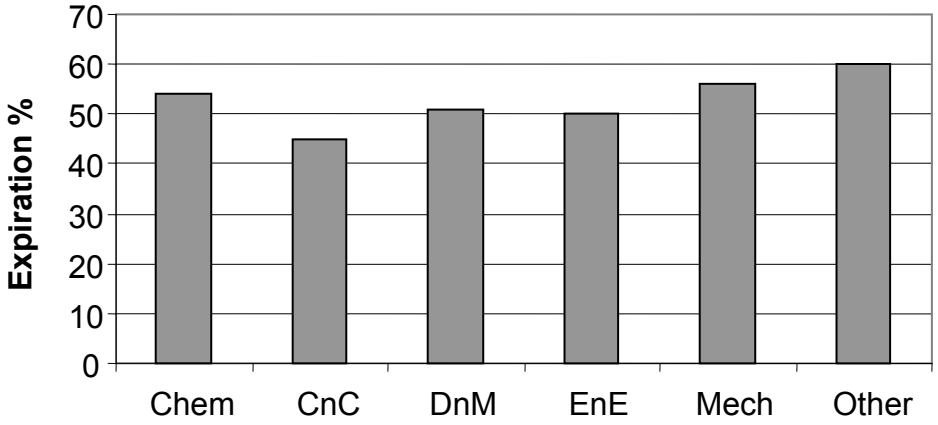
3. Characteristics of the Technology

Table 3 illustrates the percentage of expired or unexpired patents in each particular industry. Figure 1 below shows what percent of patents in a given industry (technology) group expired. Payment of maintenance fees varies sharply across technology fields. Communications and computer, drug and medical, and electrical 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.

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

Table 3: Industry distribution by patent category (%)					
	All Unexpired Patents	**Patents expired in 12 yrs.**	**Patents expired in 8 yrs.**	**Patents expired in 4 yrs.**	**All Expired Patents**
Chemical industry	19	21	20	18	20
Communication and Computers	12	11	9	6	9
Drugs and Medical	9	8	9	9	8
Electrical and Electronics	19	18	17	15	16
Mechanical	22	23	23	24	24
Other	18	20	23	28	24

Fig. 1: Expiration Rate by Broad Tech Class



Patent protection is a significant source of return and the magnitude of the return varies by technology. The higher cost of research and development for pharmaceutical technology[50] may explain why pharmaceutical

50. Estimates of the average cost of drug development and testing range from $10 million to $800 million; the latter is the industry's figure. *See* Christine S. Paine, *Brand-Name Drug Manufacturers Risk Antitrust Violations By Slowing Generic Production 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). *Compare* Pharmaceutical Manufacturer's Association Intellectual Property Overview, http://www.phrma.org/issues/intprop (last visited Nov, 23, 2005), *with* Rx R&D Myths, http://www.mindfully.org/Industry/Pharma-R&D-Myths.htm (last visited Nov. 23, 2005).

patents are more likely to be maintained. Congress added most of the patent term extension provisions for the benefit of the pharmaceutical industry.[51] The greater maintenance of pharmaceutical patents may also be attributable to primarily corporate ownership, since corporations are more likely to maintain their patents.

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. Table 4 presents the regression results that estimate the effect of each particular characteristic while holding constant the effects of all other characteristics. The results indicate that the number of claims and citations received are 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 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.[52] It seems logical that applicants who more highly value a particular patent would be likely to file more

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> 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).

51. *See, e.g.*, 35 U.S.C. §§ 155A, 156 (2000) (special term extensions for pharmaceutical patents); Robert P. Merges, *One Hundred Years of Solicitude: Intellectual Property Law, 1900-2000*, 88 CALIF. L. REV. 2187, 2234 n.217 (2000) (discussing proposed extension for Claritin patent); Robert P. Merges & Glenn H. Reynolds, *The Proper Scope of the Copyright and Patent Power*, 37 HARV. J. LEGIS. 45, 50-56 (2000) (discussing efforts to extend copyright terms).

52. *See* Allison & Tiller, *supra* note 35, at 1055 (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 were highly correlated).

claims and do a more thorough prior art search prior to filing. Hence, the larger the number of citations made, the more likely maintenance fees will be paid.

Table 4: Logistic Regression Results[53]

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 (CnC)	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[54]	0.001	0.001	0.378	1.001
Citations Received	0.041	0.001	<.0001	1.042
Percent Foreign Inventorship	-0.123	0.023	<.0001	0.884
Number of 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

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

54. Removing the claims variable from the regression confirms that the number of citations made is then a significant predictor of likelihood of maintenance fee payment (p=.0010).

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 appeared important in the descriptive statistics continue to be significant in the regression. With regard to assignment of patent rights and its impact on maintenance, I omitted unassigned patents. Hence, I compare each of the other categories to unassigned patents. It is not surprising that patents assigned to individuals are maintained at the same rate as patents that are unassigned, because unassigned patents are basically a patent still owned by individuals (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 (possibly reflecting the different patenting strategies of individuals and corporations). In addition to an individual/corporation distinction in patent maintenance, there also is 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.[55]

This foreigner effect is likely due to the higher transaction costs for foreigners to obtain U.S. patents. 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 patentees would have to disclose all of the prior art from the foreign prosecution, which the U.S. examiner would then have to review prior to U.S. allowance. Thus U.S. patents acquired by foreign patentees would be stronger than those acquired by their domestic counterparts by virtue of the additional independent review. It may also be that U.S. patents are a more important signaling mechanism for foreign parties than for U.S. parties. Another possibility is that U.S. corporations are increasingly implementing internal cost-control maintenance review systems for technical obsolescence which their foreign counterparts are not doing. U.S. corporations may be better at estimating the expected return from a given patent and therefore more adept at weeding out worthless patents via maintenance fee payments.

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55. The higher the percentage of foreign inventors, however, the less likely the patent is to be maintained. Inventorship domicile is correlated with assignee domicile. Most patents which issue assigned to a foreign corporation have foreign inventors.

With regard to technology, I used the mechanical group as the baseline for the regression shown in Table 4. Accordingly, each of the other categories is significant if it is sufficiently different from the mechanical group. Chemical, Drugs and Medical, and Other Industries are less likely to be maintained than mechanical patents. Electrical and Electronics and Communications and Computer 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 standard assumption that patent rights are more important in industries with high research and development costs.[56]

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.[57] It may be that these industries rush to patent new compounds and genes (and their methods of manufacture) before knowing whether those compounds have great utility or commercial viability.[58]

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56. *See* 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); Allison, *Valuable Patents, supra* note 9 (discussing industry-specific patterns of patent value); Allison & Lemley, *supra* note 35, at 2146 (showing substantial variation by industry in the nature and importance of patents); Hall & Ziedonis, *supra* note 5, at 104 (noting the primarily defensive use of patents in the semiconductor industry); 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); 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, 92 (1998) (finding that the private value of patent rights in France differed by technology field); Ashish Arora et al., *R&D and the Patent Premium* 1, 33 (2002) (working paper, on file with author) (demonstrating that patents give greater returns in some industries than others); 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. Research, Working Paper No. W7552, 2000) (finding differences across industries in the use of patents relative to other methods of protecting intellectual property).

57. *See* Brief for Biotechnology Industry Organization as Amici Curae at 4, Knorr-Bremse Systeme Fuer Nutzfahrzeuge GMBH v. Dana Corp., 383 F.3d 1337 (2004) ("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.").

58. *See, e.g.*, 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

Recognizing that the technology categories controlled for in the regression above may be overly broad, I subdivided the technology categories into thirty-six subcategories.[59] 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. I used biotech as the comparison point.[60] 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 also are more likely to be maintained than biotech patents. But biotech patents are more likely to be maintained than drug patents and agricultural and organic compounds patents. Biotech patents also 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. Simple devices include amusement devices, furniture or house fixtures, apparel and textile, and receptacles. It appears that biotech patents are more likely to be maintained than most mechanical inventions, suggesting that the initial breakdown 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 than this subgroup may have been driving the earlier results.

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sequencing technology and the Human Genome Project provided the impetus for a flood of gene discoveries and patents").

59. The sub-category definitions are from Hall et al., *supra* note 34, at 41-42.

60. In a regression with qualitative explanatory variables as I have here, I create and use dummy variables to measure the impact of each category of the qualitative variable. Here, for instance, I have thirty-six different dummy variables, one 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. 1992).

Table 5: Regression results by technology subcategories

Industry Sub-category	Estimate β	Standard Error	Signifi-cance 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 & Joint – Other	0.115	0.090	0.203
Receptacles – Other	-0.184	0.073	0.012
Miscellaneous – Other	-0.027	0.064	0.675

The hierarchy of technology in terms of the likelihood of renewal is as follows in Figure 3:

Figure 3. Classes in which patents are likely to be renewed		
More Likely To Be Maintained	↑	semiconductors—electrical (0.309) optics—mechanical (0.302) information storage—CnC (0.280) computer peripherals—CnC (0.263) miscellaneous electrical—electrical (0.246) electrical devices—electrical (0.216) communications—CnC (0.185) computer hardware and software—CnC (0.146) biotech (and all others not specifically listed) 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—chemical (-0.349)

By using likelihood of patent maintenance, this study measured long term patent value or delayed patent value. This is different from patent value at any specific point in time. The fact that patents on computer-related inventions are more likely to be maintained than those on biotech is surprising. My intuition suggested that in fields of rapid development, 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 changed so drastically. Of course, these patents could be more valuable in the early part of their term. In fact, they may have generated more revenue or protected more market share for their owner in those early years than a new drug patent because new drugs often spend their first few years in review at the FDA. I thought that patents whose value is front-end loaded would appear to be less valuable than patents whose value is back-end loaded. In actuality, my 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.[61]

This unexpected disparity may have to do with the underlying patenting patterns of the biotech industry. Biotech companies often rush to patent before sufficient product and market research can ascertain the commercial viability of the resultant product. A software or hardware patent is generally not filed until a tangible product exists—either a written program or designed hardware. Hence, these sorts of patents are generally filed in a later developmental stage. Biotech, pharmaceutical, and chemical compound patents, in contrast, are generally filed in an earlier research stage where end results or uses are still uncertain.[62] Hence, in the biotech or pharmaceutical area there is a higher variance in patent value.

This model with finer technical classifications and less resultant technical variation indicates that the other identified characteristics (claims, cites received, etc.) continue to indicate value regardless of technology type. Hence, while technology type may temporally affect when a patent's value is fully realized, the other characteristics studied have no temporal aspect. For example, there is no reason to think that the number of claims would affect when in the lifetime of the patent that it would yield value to the patentee. Whereas cost recovery differences (such as R&D) between technology categories influence the value of patents, there are no major cost recovery differences that influence the number of claims in a patent application.

Semiconductor patents are one example of industry-specific empirical findings on renewal rates that yield unexpected results. Two major studies of the semiconductor industry, the Yale and Carnegie Mellon studies, each reported that patents were among the least effective mechanisms for ap-

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61. The dataset of patents issued in 1991 likely does not have a large number of software patents because it was prior to the Federal Circuit's decision in *In re* Alappat, 33 F.3d 1526 (1994). This case effectively opened 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, 326-27 (1999).

62. 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. *See* Dan L. Burk & Mark A. Lemley, *Policy Levers in Patent Law*, 89 VA. L. REV. 1575, 1645-46 (2003) (explaining that the utility guidelines raise 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"); *cf.* 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).

propriating returns from research and development expenditures.[63] The studies 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.[64] Contrasting the survey evidence that suggested 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."[65] A study by Hall and Ziedonis found that, among capital-intensive firms in the semiconductor industry, patenting seemed to be used extensively as a defensive strategy—a "patent portfolio race."[66] My finding that patents on semiconductor inventions are the most likely to be renewed of all the different industries certainly undermines the contention that the semiconductor industry does not value patent rights.[67]

III. GETTING A CLEARER SENSE OF VALUE: COMPARING PATENTS THAT EXPIRED FOR FAILURE TO PAY MAINTENANCE FEES WITH LITIGATED PATENTS

Comparing and contrasting the data on worthless patents with my 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), the 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).[68] The data on litigated patents does not contain 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 comparison would be more appropriate with the data on expired and unexpired patents in this study. The closest comparison I can make at this time is with the database of litigated patents from

63. Levin, *supra* note 56, at 794-98; Cohen, *supra* note 56, at 9-11; Hall & Ziedonis, *supra* note 5, at 102.

64. Hall & Ziedonis, *supra* note 5.

65. *Id.*

66. *Id.* at 125.

67. *See supra* note 64 and accompanying text. My finding in the litigation-based study is that despite the high rate of semiconductor patenting, there is a low rate of semiconductor litigation. This further substantiates the contention that the semiconductor industry, more so than other industries, uses patents defensively to ensure cross licensing and to avoid hold-ups. *See* Allison, *Valuable Patents*, *supra* note 9, at 472.

68. For a discussion of the data on issued patents and litigated patents, see Allison, *Valuable Patents*, *supra* note 9.

1999-2000. Because patent characteristics have changed over time,[69] a straight-forward comparison of patents 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 years post-issuance)	Issued Patents (Unexp. Pats--1991)	Issued Patents (1976-1999)	Valuable Patents (Litigated Patent)
Number of Claims	12.0 (11.5, 12.0, 12.7)	13.3	13.0	19.6
Number of Cites Made	7.51 (7.39, 7.55, 7.53)	7.78	8.43	14.20
Number of Cites Received	4.72 (4.16, 4.77, 5.79)	7.40	4.32	12.23
Number of 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
Number of Inventors	1.96 (1.81, 1.99, 2.07)	2.16	2.10	1.86
Percent Foreign	47 (44, 47, 50)	48	46	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).[70] Expired patents had fewer claims than unexpired patents, which, in turn, had fewer claims that litigated patents. Fewer U.S. prior art cites were considered

69. Hall et al., *supra* note 34, at 14-16, 23-24 (finding that patent citation and claiming practice has changed over time).

70. Given the high litigation costs, litigated patents are a subset of all valuable patents. As discussed, there are a number of ways in which patents may be valuable to their owners, including signaling, licensing, and providing defense. Many valuable patents are never 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 Allison, *Valuable Patents*, *supra* note 9, at 439-43.

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 do not, however, consistently signify value. 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.

Does this mean that this characteristic is 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*, I 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.[71] Characteristics of the person or patentee (such as foreign/domestic and individual/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. Patent value is not only determined by litigation. 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 electronics 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 communications and computer technology, patenting decisions are made late in the developmental process, when software is written or hardware is designed. Accordingly, patenting in these industries is more predictive of commercial value. Patent-

71. Moore, *Xenophobia in American Courts*, *supra* note 4, at 1504.

ing in the biotech, pharmaceutical, and chemical industries generally occurs at earlier stages of product development. Therefore, these patents are more like a lottery. However, given the relatively high research and development costs in these industries, the patents that do result in commercial products are very important to the patentee's ability to recoup costs. This explains the high litigation rates.

A comparison of the finer technical classifications supports this theory as well.[72] Some categories such as optics, communications or electronics have both a high litigation rate and a high maintenance rate. Other categories with inconsistent litigation and maintenance rates follow the preceding pattern: a combination of development stage and research and development costs influence maintenance and litigation rates in opposite ways.

There is an alternative explanation for why some industries have high rates of renewal but low rates of litigation. Industries not only value patents differently in terms of their ability to protect intellectual assets and recoup R&D expenditures, but also value them for different reasons.[73] Some industries 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 patents owned, whereas litigation data confirms the specific value as revenue generation.

Industry variation in litigation rates and renewal rates significantly affects the study of the patent system, patent policy and patent value. Renewal rates estimate value better than litigation rates because renewal rates respond to the many ways patents may be of private value. Litigation rate data would never identify patents whose value stems from defensive use in a large portfolio or use as a signal to consumers, competitors or venture capitalists. Finally, there are valuable patents that generate significant licensing revenue and are never litigated. Since litigated patents are only a subset of valuable patents and may not be a representative subset, renewal data is a more objective measure of value. Moreover, renewal data eliminates many of the personal idiosyncrasies that appear in litigation data. Foreign parties are frequently averse to litigation, and individuals and corporations have different patenting strategies.

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72. A direct comparison of the finer technology classifications is not straightforward since the classifications herein are based on the PTO classification system, whereas the finer classifications in the Valuable Patents paper were done by hand. *See* Allison, *Valuable Patents*, *supra* note 9, at 456.

73. This explanation is consistent with the economic literature. The literature concludes that patents play different roles in different industries. *See supra* note 56.

In addition to differences in qualitative value between litigation and renewal rate data, there is a difference in quantitative value. Renewal rate data identifies patents whose value to their owner is at least the cost of the maintenance fees ($900-$6,200),[74] whereas litigation rate data identifies patents whose value is generally much higher quantitatively. For example, a patent in litigation may be valued based on the price the owner is willing to pay for the litigation – the litigation costs and attorneys fees. The further the litigation progresses the more money the litigation costs and the more valuable the patent must be to its owner.[75] Hence renewal data is useful to analyze a broader range of valuable patents. Finally, since the litigation rate data and the renewal rate data agree on which characteristics of the patents are likely to be indicia of patent value, they confirm the role of the patent characteristics for patent valuation.

IV. 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 ask whether the patent system is an effective incentive mechanism for spurring innovation and disclosure; some people question the very existence of a patent system.[76] 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.[77] Since patenting is just one of several alterna-

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74. *See supra* note 24 and accompanying text.

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

76. 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); *see also* 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, 419-21 (1985) (concluding that present knowledge does not strongly justify immediate abolishment of the patent system).

77. *See* James Bessen & Eric Maskin, *Sequential Innovation, Patents, and Imitation* (MIT Dep't of Econ. Working Paper No. 00-01, 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

tive 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. In particular, the difference in returns from the invention with and without patent protection is relevant. The patentee's estimate of the incremental value determines both whether to file patent applications and whether to renew patents. The empirical evidence in this Article provides information on the value of patent protection and how that value may vary.

While many scholars have attempted to use patent counts (the total number of patents issued annually) to measure innovative output,[78] the high percentage of patent expirations found in this study shows that patents vary greatly in 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

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proposals. *See, e.g.*, 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); 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); Peter S. Menell, *Tailoring Legal Protection for Computer Software*, 39 STAN. L. REV. 1329 (1987) (arguing for *sui generis* protection for computer software); J.H. Reichman & Pamela Samuelson, *Intellectual Property Rights in Data?*, 50 VAND. L. REV. 51, 64-109 (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, 2332-2432 (1994) (discussing a *sui generis* regime for protecting computer software). 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 of biotechnology); S. Benjamin Pleune, *Trouble With the Guidelines: On Urging the PTO to Properly Evolve with Novel Technologies*, 2001 J. TECH. L. & 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.A. § 103(b) (2005); Burk & Lemley, *supra* note 62, at 1577. Semiconductor chips and plants have, in fact, received *sui generis* legislative protection. 7 U.S.C. § 2401 (2004) (plant variety protection act rights); 17 U.S.C.A. §§ 901-914 (West 2005) (semiconductor chip rights); 35 U.S.C. §§ 161-164 (2004) (plant patent rights); *see also* Mark D. Janis & Jay P. Kesan, *U.S. Plant Variety Protection: Sound and Fury?*, 39 HOUS. L. REV. 727, 730-46 (2002) (discussing the emergence of *sui generis* systems for plant variety protection).

78. *See* Lanjouw et al., *supra* note 28, at 406 (lamenting the use of patent counts as a flawed measure of innovative output); Ariel Pakes & Margaret Simpson, *Patent Renewal Data*, *in* 1989 BROOKINGS PAPERS ON ECON. ACTIVITY: MICROECONOMICS 331, 363-65 (explaining the problems with using patent counts as a measure of inventive activity).

value of the patent to both the patent owner and competitors, since competitors are unlikely to infringe a patent of low value. But litigation rate data are limited to identifying patents that are valuable to their owners primarily for revenue generation. Litigation data ignore other forms of private value that may exist for patents (e.g., defensive or signaling value). The fact that certain patent characteristics do predict likelihood of patent maintenance and the likelihood of patent litigation suggests that they are useful predictors of value.

Here, I have used patent maintenance data to identify *ex ante* valuable patents. Generally, patent maintenance 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 demonstrate that patentees are able to identify the innovative value of technology as soon as three and a half years after a patent issues, likely because of decreased uncertainty in the technology. There is no way of knowing with great precision *ex ante* the twists and turns technology will take after disclosure. It may be that an industry widely embraces a given technology, resulting in a huge return for the patentee; on the other hand, competitors may successfully create design alternatives.

The data permit some generalities. For example, patentees obviously rush to patent before ascertaining meaningful estimates of the expected return of any given technology. 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-invent patent system, it would likely be exacerbated if the U.S. adopted the first-to-file system of every other country. This major reform proposal is 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 may in fact be optimal. Although the current system is heavily criticized, it would be inefficient for the PTO to spend more time evaluating worthless applications.[79]

Finally, Congress should review the current schedule of patent maintenance fees. It may be possible to redesign the PTO maintenance fee schedule more strategically to increase social welfare.[80] Since renewal fee

79. *See* Mark Lemley, *Rational Ignorance at the Patent Office*, 95 NW. U. L. REV. 1495, 1496 (2001) (suggesting that it would be inefficient for the PTO to spend more time on patent applications).

80. *See* Francesca Cornelli & Mark Schankerman, *Patent Renewals and R&D Incentives*, 30 RAND J. ECON. 197, 197 (1999) (finding that revising the patent renewal fee schedule for high R&D productivity firms to have renewal fees rise more sharply with patent term length would yield significant welfare gains).

requirements and the payment thereof determine effective patent term, the renewal fee schedule could adapt to differing technologies. An annual renewal fee, like those found in most countries, may have advantages over the current four year fee schedule or alternative fee schedules that vary based on the term of the patent. Annual renewal fee schedules would likely result in technology entering the public domain sooner. An annual renewal fee schedule would be unlikely to impact disclosure or patent filings given the high cost of patent acquisition relative to the maintenance fees. 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 to encourage more rapid transfer to the public domain. Maintenance data is an area ripe for additional research. Maintenance data helps identify the characteristics of valuable patents, which is useful in patent valuation theory as well as for targeting reforms to the Patent and Trademark Office. This is one use, but there are undoubtedly other uses of maintenance data.