

2007

Software Patents, Incumbents, and Entry

John R. Allison
John.Allison@mcombs.utexas.edu

Abe Dunn
abedunn@mail.utexas.edu

Ronald J. Mann
Columbia Law School, rmann@law.columbia.edu

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Recommended Citation

John R. Allison, Abe Dunn & Ronald J. Mann, *Software Patents, Incumbents, and Entry*, TEXAS LAW REVIEW, VOL. 85, P. 1579, 2007; U OF TEXAS LAW, LAW & ECONOMICS RESEARCH PAPER NO. 105 (2007).
Available at: https://scholarship.law.columbia.edu/faculty_scholarship/1473

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THE UNIVERSITY OF TEXAS SCHOOL OF LAW

85 Texas Law Review (2007)

Law and Economics Research Paper No. 105
June 2007



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John R. Allison

The University of Texas McCombs School of Business

Abe Dunn

U.S. Department of Justice

Ronald J. Mann

The University of Texas School of Law

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Texas Law Review

Volume 85, Issue 7, June 2007

Symposium

Software Patents, Incumbents, and Entry

John R. Allison,^{*} Abe Dunn^{**} & Ronald J. Mann^{***}

I. Introduction

Software patents have been controversial since the days when “software” referred to the crude programs that came free with an IBM mainframe. Different perspectives have been presented in judicial, legislative, and administrative fora over the years, and the press has paid as much attention to this issue as it has to any other intellectual property topic during this time. Meanwhile, a software industry developed and has grown to a remarkable size, whether measured by revenues or profitability, number of firms or employees, or research expenditures. The scope of software innovation has become even broader, as an increasing number of devices incorporate information technology, requiring modern manufacturing firms outside the software industry to employ developers and programmers to ensure that increasingly diverse functions are performed more efficiently.

Although inventors have consistently asserted their need for patents in order to compete with industry incumbents, patent protection has not been easily or consistently available for much of this period. Rather, the legal system has responded gradually to the burgeoning software industry by broadening the scope and strength of protection for software-related inventions in fits and starts. The explosive growth of the industry is largely attributable to demand generated by the efficiency of software solutions; the expansion of the venture capital industry over the same period largely

^{*} Spence Centennial Professor of Business Administration, McCombs School of Business, University of Texas at Austin.

^{**} Economist, U.S. Department of Justice.

^{***} Ben H. & Kitty King Powell Chair in Business and Commercial Law and Co-Director, Center for Law, Business, and Economics, University of Texas School of Law. We thank for comments Rosemarie Ziedonis as well as participants at the Frontiers of Intellectual Property Conference. The views expressed are not those of the U.S. Department of Justice. © 2007 John R. Allison, Abe Dunn & Ronald J. Mann.

explains the lack of industry concentration.¹ The “garage” mentality can be explained by the fact that even some of the largest industry incumbents began with one or two (largely unfunded) inventors. Also, there is every reason to believe that increased patent protection has contributed to the ability of independent inventors and smaller firms to compete.²

Moreover, the ability to obtain patents on software always has been important to some of the industry incumbents, while others have exhibited little need for patents and displayed, in some cases, strenuous opposition to the patentability of software. The incumbents are a diverse group. Some produce only software; others have substantial hardware product lines. Some sell to other technology firms and others sell applications to end users in a broad range of markets. And some sell prepackaged software products, while others focus on services—custom programming, installation, or maintenance. Regardless of the sector in which they participate, the incumbents spend massive amounts on research and development (R&D)—about 14% of their annual revenues, more than \$60,000 per employee.³ However, there are important patterns in patenting practices that raw data on R&D investments cannot explain.

This Article examines the relation between patents and the different business models used by firms in the software industry. The analysis has four parts. Part II provides a brief retrospective on software patents, emphasizing the shifting role of patents as the industry grew into its modern form. Part III uses quantitative data about patent portfolios to discuss the role that patents play for incumbent firms in the modern era. We highlight the fact that business models explain much of the pattern of patenting practices. Part IV describes the use of patents in the three channels through which technology flows into incumbent firms—venture-backed firms, open-source developers, and independent inventors—all of which contribute to the development of technologies that might supplant or improve the products and services currently delivered by incumbent firms. Finally, Part V concludes with a brief discussion of present-day industry perspectives on software patenting. As incumbents are now leading the charge on patent reform on all fronts,⁴ we can expect that some change will occur. An understanding of the

1. The number of venture capital investments in software firms increased rapidly during this period, from 11 in 1979, to 188 in 1989, to 1,035 in 1999. NAT'L VENTURE CAPITAL ASS'N, YEARBOOK 48 (2004).

2. The question of incentives is more difficult, given the important roles played both by young entrepreneurs who have earned millions or even billions of dollars in this industry and by open-source developers driven, at least in part, by altruistic motives.

3. *Corporate R&D Scorecard*, TECH. REV., Sept. 2005, at 56, 57, available at http://www.technologyreview.com/articlefiles/2005_rd_scorecard.pdf.

4. See, e.g., *Perspectives on Patents: Post-Grant Review Procedures and Other Litigation Reforms: Hearing Before the Subcomm. on Intellectual Property of the S. Comm. on the Judiciary*, 109th Cong. (May 23, 2006) (statement of Mark Chandler, Senior Vice President and General Counsel, Cisco Systems, Inc.) (“[O]ur patent litigation system is broken.”), available at http://judiciary.senate.gov/testimony.cfm?id=1911&wit_id=5366; Brief of the Business Software

varying uses to which software firms put patents in their businesses provides a useful perspective on the types of reforms they advocate.

II. The Rise of Software Patents

A. Background

Patent debates often focus on the statements and positions taken by noted industry participants.⁵ Thus, it is common to hear that “even IBM once

Alliance as Amicus Curiae in Support of Petitioner at 1–2, *KSR Int’l Co. v. Teleflex Inc.*, 127 S. Ct. 1727 (2007) (No. 04-1350) (arguing on behalf of leading software and hardware companies against the Federal Circuit’s standard for determining nonobviousness and in favor of a less restrictive standard); Brief of Amicus Curiae International Business Machines Corp. in Support of Neither Party at 5–6, *KSR*, 127 S. Ct. 1727 (No. 04-1350) [hereinafter Brief of IBM in *KSR*] (arguing against the Federal Circuit’s standard for determining nonobviousness as overly restrictive and in favor of a rebuttable presumption that skilled artisans will combine elements found in references within “analogous art”); Brief of Business Software Alliance et al. as Amici Curiae in Support of Petitioners at 1–3, *eBay Inc. v. MercExchange, L.L.C.*, 126 S. Ct. 1837 (2006) (No. 05-130) [hereinafter Brief of Business Software Alliance in *eBay*] (arguing on behalf of leading software, hardware, digital-content, and information-technology products and services companies against the Federal Circuit’s mandatory injunction standard and in favor of the traditional equitable principles governing injunctive relief); Brief of International Business Machines Corp. as Amicus Curiae in Support of Neither Party at 2, *eBay*, 126 S. Ct. 1837 (No. 05-130) [hereinafter Brief of IBM in *eBay*] (arguing against the Federal Circuit’s mandatory injunction standard and in favor of traditional equitable principles governing injunctive relief); The Peer to Patent Project: Community Patent Review, <http://www.communitypatent.org> (describing the community patent review initiative sponsored by IBM and other incumbents).

5. Surely the most discussed statements come from the 1994 hearings of the U.S. Trademark and Patent Office (PTO) on the propriety of software patents, where trenchant criticisms of software patents were made. Thus the principal scientist at Adobe Systems, Inc. testified unequivocally: “I believe that software per se should not be allowed patent protection. . . . I argue that software should not be patented, not because it is difficult to do so, but because it is wrong to do so.” *Public Hearing on Use of the Patent System to Protect Software-Related Inventions: Before Bruce A. Lehman, Assistant Secretary of Commerce and Commissioner of Patents and Trademarks*, U.S. Patent and Trademark Office 16 (Jan. 26–27, 1994) (statement of Douglas Brotz, Principle Scientist, Adobe Systems, Inc.), available at <http://www.uspto.gov/web/offices/com/hearings/software/sanjose/sjhrng.pdf>. A witness for Autodesk, Inc. contended that “[t]here is absolutely no evidence whatsoever, not a single iota, that software patents have promoted or will promote progress.” *Id.* at 48 (statement of Jim Warren, Member of the Board of Directors, Autodesk, Inc.). Oracle’s senior vice president expressed a similar view. *See id.* at 23 (statement of Jerry Baker, Senior Vice President, Oracle Corp.) (“I cannot find any evidence that patents for software will tend to [promote the progress of science and useful arts]. [I]ndeed, every indication is to the contrary.”). On the other hand, major trade groups and software firms testifying at the same hearings expressed strongly held views that patent protection was important. So, for example, representatives of Apple and the Computer and Business Equipment Manufacturing Association, *id.* at 8–10 (statement of Richard LeFaivre, Vice President of Advanced Technology, Apple Computer, and Computer and Business Equipment Manufacturing Association), of IBM, *id.* at 78–79 (statement of Victor Siber, Senior Corporate Counsel, IBM Corp.), of Microsoft, *id.* at 66 (statement of William Neukom, Vice President of Law and Corporate Affairs, Microsoft Corp.), and of the Business Software Alliance, *Public Hearing on Use of the Patent System to Protect Software-Related Inventions: Before Bruce A. Lehman, Assistant Secretary of Commerce and Commissioner of Patents and Trademarks*, U.S. Patent and Trademark Office 18 (Feb. 10–11, 1994) (statement of Dianne Callan, Deputy General Counsel, Lotus Development Corp.), available at <http://www.uspto.gov/web/offices/com/hearings/software/arlington/vahrng.pdf>, all provided testimony supporting the patentability of software. Microsoft’s adherence to this position is notable in light of the \$120 million verdict

was opposed to patents,” or “Microsoft did fine without patents,” or even “we wouldn’t have Word, Excel, or PowerPoint if earlier inventors had been able to acquire patent protection.” There is a similar focus on market responses. Thus prominent academics point to the limits on patent protection available to the software industry in its earliest days as evidence that software could succeed in the market without patent protection.⁶ Of course, what we also see is that software patents did become important, largely because of market pressures. All of this raises the question whether the software industry would be more competitive or innovative in a “natural state,” that is, without patent protection.⁷

entered against it a few days earlier in *Stac Electronics v. Microsoft Corp.*, 38 F.3d 1222 (Fed. Cir. 1994). See Lawrence M. Fisher, *Microsoft Loses Case on Patent*, N.Y. TIMES, Feb. 24, 1994, at D1 (discussing the verdict in favor of Stac Electronics in a patent-infringement suit alleging that Microsoft had appropriated Stac’s data-compression technology).

6. See, e.g., Pamela Samuelson, *Benson Revisited: The Case Against Patent Protection for Algorithms and Other Computer Program-Related Inventions*, 39 EMORY L.J. 1025, 1143 (1990) (“Thus, let us accept as a working assumption that the computer software industry has become a major industry without the aid of patents, and that had patents been in place in the industry’s infancy, the field would not have grown as it has.”). Surveys of individual software engineers in the late 1980s suggest that this perspective was widespread among engineers at that time. See Pamela Samuelson & Robert J. Glushko, *Comparing the Views of Lawyers and User Interface Designers on the Software Copyright “Look and Feel” Lawsuits*, 30 JURIMETRICS J. 121, 135 (1989) (finding opposition to patent protection for various aspects of computer programs, including algorithms); see also Samuelson, *supra*, at 1031–32 (“If the software industry neither wants nor needs the patent system in order to be a vital and innovative industry, then, as a matter of public policy, it is sensible not to use the patent system for the protection of program-related innovations.”).

7. For example, in an article in *PC Magazine*, the columnist John Dvorak argued that software patenting is even bad for Microsoft. John C. Dvorak, *Software Patents: Microsoft’s Fatal Error*, PCMAG.COM, Apr. 6, 2005, <http://www.pcmag.com/article2/0,1759,1781181,00.asp>. Still, recent scholarship strongly suggests that software patents have private value to the firms that obtain them. See Ronald J. Mann & Thomas W. Sager, *Patents, Venture Capital, and Software Startups*, 36 RES. POL’Y 193, 205–07 (2007) (presenting data indicating that patenting is related to the progress of venture-backed software firms); John R. Allison & Ronald J. Mann, *The Disputed Quality of Software Patents*, 85 WASH. U. L. REV. (forthcoming 2007) (manuscript at 30–32, on file with authors) (finding, among other things, that software patents have significantly more total prior art references, nonpatent prior art references, forward citations, total claims, and independent claims than nonsoftware patents issued to the same group of firms in the software industry); Iain M. Cockburn & Megan J. MacGarvie, *Entry, Exit and Patenting in the Software Industry* 33 (Nat’l Bureau of Econ. Research, Working Paper No. 12563, 2006) (finding that firms holding software patents associated with a particular market are more likely to enter and less likely to exit that market); Bronwyn H. Hall & Megan MacGarvie, *The Private Value of Software Patents* 31 (Nat’l Bureau of Econ. Research, Working Paper No. 12195, 2006) (concluding that “the market evaluated software patents as unimportant ex ante” but ex post “firms in the ICT section that hold software patents are . . . valued at a significant premium relative to firms without software patents”); Michael Noel & Mark Schankerman, *Strategic Patenting and Software Innovation* 4–5 (Ctr. for Econ. Policy Research, Discussion Paper No. 5701, 2006), available at <http://ssrn.com/abstract=922111> (concluding in an empirical study of the effect of software patents on R&D and market value in the software industry that there are large positive technology spillovers from software R&D, but that patenting by rivals reduces R&D investment, patenting rates, and market value, as well as finding a substantial patent premium in the market valuations of software firms); Robert P. Merges, *Patents, Entry and Growth in the Software Industry* (Aug. 1, 2006) (unpublished manuscript), available at <http://ssrn.com/abstract=926204> (debunking the portfolio thesis by showing that patent effort by incumbent firms correlates closely with indicators of market success).

Turning to the present, the narratives are more organized in some respects,⁸ but less predictable in others.⁹ There is also the question of why technology firms have such divergent reactions to software patents, compared to say the pharmaceutical industry where there is a dominant consensus that vigorous patent enforcement is the best policy. Our discussion suggests a simple explanation for the different perspectives: firms in the industry generally have supported software patents when it would be helpful to their competitive position.¹⁰ The divergent perspectives simply reflect divergent uses of patents for particular firms.

B. *The Early Days: From Goetz to Diehr*

In reality, software patenting predates the controversies of the 1990s and, indeed, predates the software industry itself. Thus, although it might be a stretch to credit Samuel Morse with the first software patent,¹¹ it is plain that Bell Labs received an important software patent in 1951 for its “Error-Detecting and Correcting System.”¹² Within the modern software industry,

8. The most significant opponents of software patents in the United States are Richard Stallman and the Free Software Foundation. The Free Software Foundation often participates as an amicus in patent cases, *see, e.g.*, Brief of Amicus Curiae Electronic Frontier Foundation in Support of Petitioner, *KSR*, 127 S. Ct. 1727 (2007) (No. 04-1350), and also presents testimony in congressional hearings, *see, e.g.*, *The Digital Media Consumers’ Rights Act of 2003: Hearing on H.R. 107 Before the Subcomm. on Commerce, Trade, and Consumer Protection of the H. Comm. on Energy and Commerce*, 108th Cong. 15–22 (2003) (statement of Lawrence Lessig, Professor of Law, Stanford Law School, and member of the Free Software Foundation Board of Directors). *See also* Free Software Foundation, Opinion on Patent Retaliation, <http://gplv3.fsf.org/patent-dd2.html> (last modified Aug. 3, 2006) (explaining changes to the new GPLv3 that target patent “aggression” by server operators who sue others for patent infringement for using and sharing improved versions of programs covered by the GPL). That perspective is more widely held in the European Union and elsewhere outside the United States, *see, e.g.*, FLORIAN MUELLER, NO LOBBYISTS AS SUCH: THE WAR OVER SOFTWARE PATENTS IN THE EUROPEAN UNION (Wendy M. Grossman ed., version 1.03 2006), <http://www.no-lobbyists-as-such.com/NoLobbyistsAsSuch.pdf>, where the opposition to software patents is bound up with balance-of-trade concerns. In the European Union, for example, protection of software patents is generally regarded as transferring power and wealth from fledgling European firms to existing U.S. incumbent firms. *See, e.g.*, Press Release, Foundation for a Free Information Infrastructure, Single EU Patent Law Good for US Giants, Bad for Small EU Firms (Apr. 4, 2007), available at http://press.ffii.org/Press_releases/Single_EU_patent_law_good_for_US_giants%2C_bad_for_small_EU_firms (describing opposition to a European Union-wide patent law by a European nonprofit representing more than 3,000 smaller information-technology firms on the grounds that it would benefit large U.S. companies at the expense of small European firms).

9. As discussed below, incumbent firms have widely varying patenting strategies, which have led to different positions on important policy issues.

10. Despite high-profile cases requiring changes to Office, Windows, and Internet Explorer, Microsoft executives continue to extol the virtues of software patents. *See* Bradford L. Smith & Susan O. Mann, *Innovation and Intellectual Property Protection in the Software Industry: An Emerging Role for Patents?*, 71 U. CHI. L. REV. 241, 256–58 (2004) (listing reasons why patent protection is superior to copyright in an article coauthored by two Microsoft executives).

11. *See* GREGORY A. STOBBS, *SOFTWARE PATENTS* § 5.10[E][1], at 50, 53 (2d ed. cum. supp. 2006) (characterizing Morse’s famous telegraph patent of the 1840s as a precursor to modern software patents).

12. U.S. Patent No. 2,552,629 (issued May 15, 1951).

Martin Goetz's 1968 patent often is regarded as the first "true" software patent.¹³ As Goetz's memoirs explain, the ability to patent his software was central to his firm's competitive position.¹⁴ Because Goetz was working at a period when IBM still bundled software with hardware—so that the software was effectively free if purchased from IBM—the only way of staking out a competitive foothold would be to prevent IBM from copying his product.¹⁵ A patent was the only apparent technique by which Goetz could obtain protection.¹⁶ And those who have studied the market have concluded that the patent served its function well because its disclosure was so thorough that it gave competitors who had read the patent practical access to the technology.¹⁷

IBM recognized the difficulty of obtaining intellectual property (IP) protection for software, though its market position gave it a somewhat different perspective. It opposed unbundling its software because of "[IBM's] present inability to protect the proprietary use of [its] programming systems. . . . [The Company] must settle on whether or not, and to what degree, [it] can protect programs before [it] can deal adequately with the question of selling them."¹⁸ As long as its software was bundled, IBM regularly took the position that patent protection for software was inappropriate.¹⁹ The parallel to IBM's modern involvement with Linux is startling—a market strategy in which IBM would profit from the sales of proprietary hardware in a value chain joined with free software.²⁰

Unfortunately for IBM's competitors, the industry's efforts to clarify the scope of patent protection during the 1970s were generally not fruitful. As the decade began, the case for software patenting was a strong one, based on the 1969 decision of the Court of Customs and Patent Appeals in *In re*

13. See *First Patent Is Issued for Software, Full Implications Are Not Yet Known*, COMPUTERWORLD, June 19, 1968, at 1, reprinted in Martin Goetz, *Memoirs of a Software Pioneer: Part 1*, IEEE ANNALS HIST. COMPUTING, Jan.–Mar. 2002, at 43, 51 (discussing U.S. Patent No. 3,380,029 (filed Apr. 8, 1965) (issued Apr. 28, 1968)).

14. See Goetz, *supra* note 13, at 49 (discussing the realization that patenting and copyrighting software would be essential to Applied Data Research's survival).

15. *Id.* at 50–53.

16. *Id.*

17. See Martin Campbell-Kelly, *Not All Bad: An Historical Perspective on Software Patents*, 11 MICH. TELECOMM. & TECH. L. REV. 191, 214–15 (2005) (discussing Applied Data Research's patent of Autoflow and the resulting thorough disclosure that allowed competitors to understand Autoflow and attempt to improve the program).

18. GREGORY A. STOBBS, SOFTWARE PATENTS § 1.04[A], at 39 (2d ed. 2000) (quoting testimony from 1960s IBM antitrust litigation).

19. See *U.S. Patent Court to Rehear Software Issue*, N.Y. TIMES, Mar. 1, 1969, at 43 (discussing IBM's opposition to software patents in proceedings before the PTO, aligned against Goetz's employer Applied Data Research); see also Samuelson, *supra* note 6, at 1143 (noting the early opposition to software patents by IBM and other leading hardware firms).

20. See Ronald J. Mann, *Commercializing Open Source Software: Do Property Rights Still Matter?*, 20 HARV. J.L. & TECH. 1, 26 (2006) (discussing IBM's investment in open-source software, namely Linux and Apache, and its strategy to profit by offering a value chain that uses those programs).

Prater.²¹ The Supreme Court's 1972 decision in *Gottschalk v. Benson*,²² however, brought *Prater* into grave doubt by invalidating a patent on an algorithm for converting binary-coded decimal numerals into pure binary numbers.²³ In the Supreme Court, IBM and other large hardware manufacturers opposed to the patent squared off against trade groups representing small software firms trying to gain a foothold in the industry.²⁴ Because the patent in question was regarded as weak by firms in the industry, the victory was not regarded as catastrophic, although it did diminish the enthusiasm for patent filings at the time.²⁵ The 1978 decision in *Parker v. Flook*,²⁶ invalidating a method for updating an alarm limit in a chemical process,²⁷ did not make things any better, though again the narrowness of the decision left the industry uncertain of the ultimate question of patentability.²⁸ Still, many observers at the time regarded *Parker* as a major setback.²⁹

Thus, through the 1970s and into the 1980s many firms routinely failed to patent inventions that readily would have been patented in later decades. Martin Campbell-Kelly argues forcefully that the lack of clear patent protection had adverse effects on the pace of development.³⁰ Offering an example regarding the invention of VisiCalc (a prominent early spreadsheet), he argues that the spreadsheet sector would have developed more rapidly if the inventor had patented the technology because competitors would have had access to the patent disclosure as a way to understand the technology instead of "reinventing the wheel" for themselves.³¹ Similarly, he contends that the proliferation of word processors by the early 1980s reflected wasteful

21. 415 F.2d 1393, 1405–06 (C.C.P.A. 1969) (holding that a general-purpose digital computer programmed to perform certain mathematical operations in spectrographic analysis was patentable because the computer involved programming and was not obvious under 35 U.S.C. § 103 (2000)).

22. 409 U.S. 63 (1972).

23. *Id.* at 71–73.

24. See Warren Weaver Jr., *High Court Denies Computer Patent for Programing*, N.Y. TIMES, Nov. 21, 1972, at 1.

25. See Martin Goetz, *Memoirs of a Software Pioneer: Part 2*, IEEE ANNALS HIST. COMPUTING, Oct.–Dec. 2002, at 14, 18 (suggesting that the patent was "not representative" of inventions in the industry and "never should have been filed or appealed"). For a close reading of *Benson*, arguing that it is much more hostile to software patenting than Goetz suggests, see Samuelson, *supra* note 6, at 1048–62.

26. 437 U.S. 584 (1978).

27. *Id.* at 594–96.

28. See Goetz, *supra* note 25, at 22 (noting the perceived ambiguity of *Parker*); N.R. Kleinfeld, *Software Patent Issue Is Murky*, N.Y. TIMES, June 28, 1978, at D6 (reporting Goetz's view that "[n]one of the computer programs that came before the Supreme Court is regarded by the software industry as a good example of high-level programming").

29. See Linda Greenhouse, *Court Curbs Software Patents*, N.Y. TIMES, June 23, 1978, at D1 (quoting a software-trade-association representative who argued that "the [software] industry . . . now has no Federal protection against theft by competitors," which he viewed as a "gigantic industry problem"); see also Samuelson, *supra* note 6, at 1076–83 (providing a detailed contextual analysis of *Parker*).

30. See Campbell-Kelly, *supra* note 17, at 198–99.

31. *Id.*

“overfishing” that would have been truncated if early innovators had obtained effective patent protection.³²

By the end of the 1970s, IBM’s position had changed. After it unbundled its software from its hardware in 1970, IBM entered the field of competition in which it had to sell its software products at a separate price and attempt to defend them from appropriation by competitors.³³ Pressure from newcomers to the industry, particularly those from Japan,³⁴ quickly turned IBM into an advocate for increased IP protection for software.³⁵ And with the Court’s 1981 decision in *Diamond v. Diehr*,³⁶ the way seemed open, though perhaps not yet clear, for regular patenting of the kinds of computer programs that were at the core of the rapidly growing software industry.³⁷

C. The 1980s: The PC and the First Software Patent Portfolios

The Court’s 1981 decision in *Diehr* certainly was not the most important event of the year for the software industry. IBM’s introduction of the personal computer was much more significant. Although others had sold personal computers with some success—Apple and Tandy at the time were regarded as formidable competitors³⁸—the introduction of the IBM Personal Computer (PC) transformed the software industry.³⁹ For one thing, the deployment of the IBM PC and the rapid entry of parallel IBM-compatible

32. *Id.* at 201–02, 209.

33. See Goetz, *supra* note 25, at 24–25 (discussing IBM’s move to protect its source code in response to increased competition following the unbundling of IBM software).

34. Japanese software developers benefited from the same government support as competitors in other industries on which Japan focused. See Steve Lohr, *Japan’s Hard Look at Software*, N.Y. TIMES, Jan. 9, 1983, at F4 (“[T]he full arsenal of government and industry backing is being directed at software development in Japan.”).

35. See Goetz, *supra* note 25, at 24–28 (discussing IBM’s move to maintain the secrecy of its source code so that it could use trade-secret protection for the functional ideas carried out by the code in response to increased competition following the unbundling of IBM software); Angel Castillo, *Bill Safeguards Data Programs*, N.Y. TIMES, Dec. 4, 1980, at D1 (noting IBM’s support for the Computer Software Copyright Act of 1980). IBM’s first major IP claim in the software industry came at this time when it challenged Hitachi’s incorporation into its software products of technology it claimed Hitachi had stolen from IBM. *Hitachi Disputes Fee to I.B.M.*, N.Y. TIMES, Nov. 10, 1983, at D5.

36. 450 U.S. 175 (1981).

37. See Goetz, *supra* note 25, at 22–23 (noting the positive contemporaneous response to *Diehr*).

38. Andrew Pollack, *Big I.B.M.’s Little Computer*, N.Y. TIMES, Aug. 13, 1981, at D1 (discussing IBM’s entry into the personal computer market—“a market now dominated by Apple Computer, Inc. and Tandy Corporation’s Radio Shack division”).

39. See MARTIN CAMPBELL-KELLY & WILLIAM ASPRAY, *COMPUTER 229* (1997) (stating that the IBM PC became so popular that most of the major software packages were converted to run on the machine, which encouraged other manufacturers to produce “clone” machines that ran on the same software); Pollack, *supra* note 38, at D1 (noting that the IBM PC was a direct challenge to Apple and Tandy’s dominance of the market); Andrew Pollack, *Next, a Computer on Every Desk*, N.Y. TIMES, Aug. 23, 1981, at F1 (recognizing that IBM’s entry into personal computing would change the market).

machines⁴⁰ fostered a competition for a standard operating system to be used on those machines, a competition in which Microsoft's MS-DOS system successfully dislodged the CP/M system developed by then market leader Digital Research, one of many companies fated to become bywords for a lack of market foresight in this rapidly developing industry.⁴¹ As Figures 1 and 2 display, the need to protect that operating system would make Microsoft one of the first software-products firms to invest heavily in patents as a way to protect its core technology.⁴²

The other thing that came from the deployment of the PC was a vast and previously unimaginable market for software applications to be deployed on the geometrically increasing number of personal computers in the American workplace.⁴³ This signaled the end (or at least diminished importance) of the "garage" era of software development, as the need to produce sophisticated applications rapidly called into existence a large number of large firms, all of which began to compete against each other for the attention of the limited available capital investors.⁴⁴ Not surprisingly, the fiercely competitive landscape of rapid development against a backdrop of uncertainty in legal rules led firms to adopt very different IP strategies. Adobe, like Microsoft, began to patent relatively early, apparently hoping to protect its early lead in the "Font Wars" of the late 1980s.⁴⁵

40. See Andrew Pollack, *Big I.B.M. Has Done It Again*, N.Y. TIMES, Mar. 27, 1983, at F1 (discussing the proliferation of IBM clones).

41. A common perspective is that CP/M failed because Digital Research moved too slowly to upgrade its software to accommodate 16-bit processors, leaving Microsoft's MS-DOS to gain an insuperable lead in that market before Digital Research ever entered. See MARTIN CAMPBELL-KELLY, *FROM AIRLINE RESERVATIONS TO SONIC THE HEDGEHOG: A HISTORY OF THE SOFTWARE INDUSTRY* 239 (2003) (noting that the 16-bit version of CP/M was not available until months after the launch of the IBM PC, giving Microsoft "an insuperable first-mover advantage"); David E. Sanger, *The Big Guys Get into the Act*, N.Y. TIMES, Sept. 4, 1983, at F11 (calling CP/M the "industry standard" before it lost ground to Microsoft as a result of not being able to run on 16-bit architecture).

42. See STOBBS, *supra* note 18, § 11.01[B], at 525–57 (discussing early Microsoft patents on technology related to operating systems).

43. See CAMPBELL-KELLY, *supra* note 41, at 242–64 (describing some of the thousands of software applications designed for the personal computer in its first ten years); Pollack, *supra* note 38, at D1 (discussing IBM's plans to foster widespread development of software for the IBM PC).

44. See Andrew Pollack, *Microsoft Has It All—Almost*, N.Y. TIMES, Sept. 4, 1985, at D1 (discussing the market forces leading to the professionalization of software development); Andrew Pollack, *Slugging It Out on the Software Front*, N.Y. TIMES, Oct. 16, 1983, at F1 (describing the end of the "cottage era" in software development and the beginning of the era of big software companies and correspondingly large investments).

45. See Peter H. Lewis, *The Fallout from the Font Wars*, N.Y. TIMES, Oct. 1, 1989, at F13 (noting that if Adobe had been willing to share its proprietary information earlier, it probably could have avoided the "font wars"); Andrew Pollack, *Adobe Is Set to Disclose Technology*, N.Y. TIMES, Sept. 21, 1989, at D1 (describing Adobe's plan to reveal its font technology in an effort to stay competitive with a joint Apple and Microsoft font project).

Figure 1: Patent Applications⁴⁶ per Billion Dollars in Sales
(Prepackaged Software) (1985–2001)

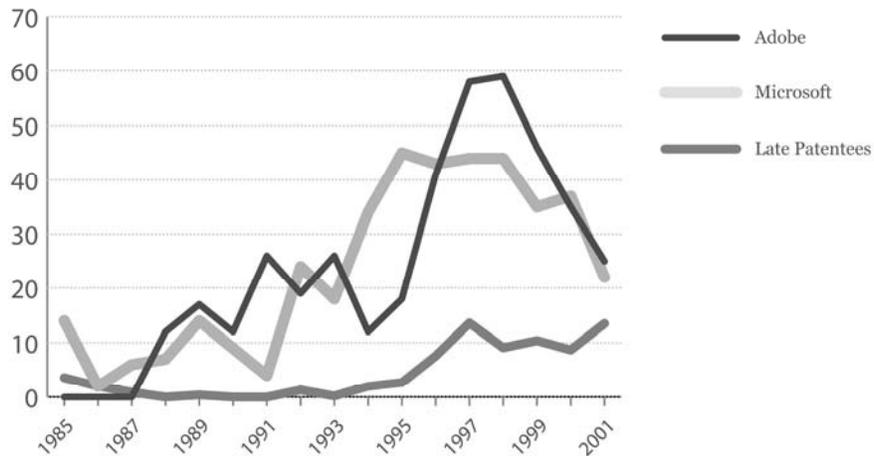
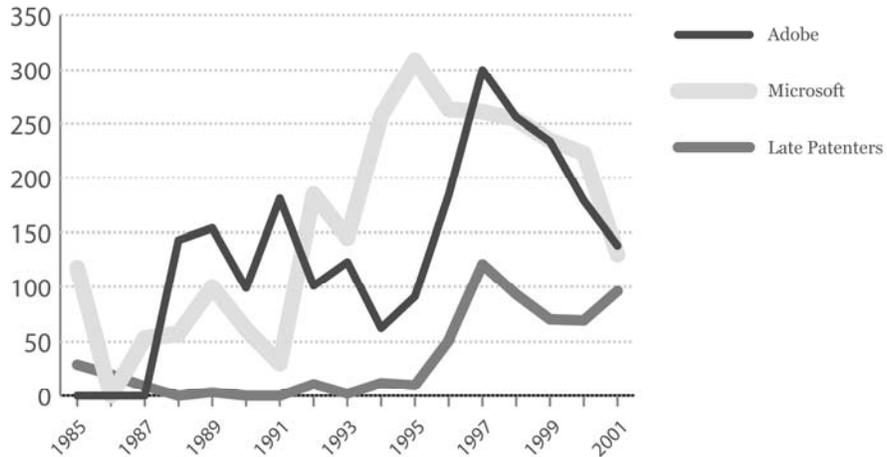


Figure 2: Patent Applications per Billion Dollars in R&D
(Prepackaged Software) (1985–2001)



46. Throughout this Article, the tables and figures attribute applications to the year in which they were filed and refer only to patent applications that resulted in issued patents.

For the most part, however, products firms⁴⁷ during the 1980s eschewed patent protection, apparently accepting the predictions of the National Commission on New Technological Uses of Copyrighted Works (CONTU)-like pundits advising that copyright law would provide adequate protection. Thus, Figures 1 and 2 group together under the title of “Late Patentees” Autodesk, Computer Associates, and Oracle (the three leading products firms of the time that have survived and have substantial patent portfolios today). Two obvious factors can explain the change of strategy. The first would be the belated discovery⁴⁸ (as the patent applications filed in the 1980s matured into issued patents) that some of their competitors already were amassing substantial portfolios.⁴⁹ There was considerable uncertainty about the reliability of software patents even after *Diehr*,⁵⁰ and firms that saw them as less crucial than Microsoft and Adobe easily could (and did) forego them. The other is the decision in *Computer Associates v. Altai*⁵¹ and its progeny such as *Lotus v. Borland*⁵² signaling the limited ongoing reliability of copyright as a system for protecting innovation in software.⁵³

D. The 1990s: Proliferation of Software Patents

As others already have documented in detail, the 1990s brought a rapid acceleration in the growth of patents in the software industry, as the problems with copyright became more evident, as the legal environment became more supportive, and as the pace of software innovation grew with the spread of

47. We discuss in more detail below the distinction between software firms that profit primarily from the sale of off-the-shelf products and those that profit primarily from the sale of software-related services.

48. One reason that the discovery was “belated” is that the PTO seems to have dragged its feet considerably in response to the patent applications that the software firms started filing in the mid-1980s, which had the effect of increasing the head start of applications that those firms had by the time their competitors learned of the applications.

49. The tone of surprise is evident from the press coverage that greeted a 1989 patent by Quarterdeck on an early form of “Windows” technology. See *Patent Is Won by Quarterdeck*, N.Y. TIMES, Apr. 19, 1989, at D4 (suggesting, wrongly as it turns out, that it was “unusual” to receive a software patent and that the patent could be more important than Apple’s battle with Microsoft over copyright protection for its graphic user interface).

50. For example, Donald Chisum argued vehemently that *Benson* needed to be explicitly overruled to clear the way for a sensible system of software patenting. See Donald S. Chisum, *The Patentability of Algorithms*, 47 U. PITT. L. REV. 959, 961 (1986) (calling the *Benson* decision poorly reasoned and inconsistent with later case law). On the other side of the issue, Pamela Samuelson argued in 1990 that the PTO had gone too far to tolerate software patents and that the courts needed to step in to prevent the proliferation of patents in the area. See Samuelson, *supra* note 6, at 1029 (restating “the case against patent protection for algorithms”).

51. *Computer Assocs. Int’l, Inc. v. Altai, Inc.*, 982 F.2d 693 (2d Cir. 1992).

52. *Lotus Dev. Corp. v. Borland Int’l, Inc.*, 49 F.3d 807 (1st Cir. 1995), *aff’d by an equally divided Court*, 516 U.S. 233 (1996).

53. See Josh Lerner & Feng Zhu, *What Is the Impact of Software Patent Shifts?: Evidence from Lotus v. Borland* (Nat’l Bureau of Econ. Research, Working Paper No. 11168, 2005), available at <http://papers.nber.org/papers/w11168.pdf> (examining the impact of the series of decisions leading to and including *Lotus v. Borland*, and presenting evidence that a reduction in copyright protection led to more patenting by interface firms).

the personal computer and then the Internet.⁵⁴ This produced a rate of patenting that was unimaginable to those in the industry just a few decades earlier.⁵⁵

To see how those factors changed the relative patenting rates among various types of software firms, we present in Figures 3 and 4 data on the patenting practices from 1990–2001 of three groups of large firms that survived throughout the entire period and now have substantial software patenting portfolios: electronics firms, prepackaged software firms, and system-design firms.⁵⁶ As those figures illustrate (with alternate data on patents as a function of sales and as a function of R&D), electronics firms already had established stable patenting practices and thus experienced only a modest rise in patenting rates from 1990–2001, while the firms in the other two sectors, more focused on software, experienced an increase of 300%–500%. The point is illustrated more clearly in Figure 5, which shows the patenting rates for one prominent firm from each sector: HP's line has only a slight upward trend, while the Microsoft and IBM lines show much steeper increases that are surprisingly parallel given the common perception that Microsoft is a relative latecomer to the patent sweepstakes.

54. See David S. Evans & Bernard J. Reddy, *Government Preferences for Promoting Open-Source Software: A Solution in Search of a Problem*, 9 MICH. TELECOMM. & TECH. L. REV. 313, 321 (2003) (noting the favorable conditions that led to the increase in software patents during the 1990s).

55. See Kleinfield, *supra* note 28, at D6 (quoting Goetz's comment that "[i]f the Patent Office were to become receptive to giving out patents on software, I doubt that there would be more than a few hundred applications a year").

56. The firms are distinguished by three-digit North American Industry Classification System (NAICS) codes: 334 for the electronics firms (Apple, EMC, HP, NCR, Qualcomm, and Sun), 511 for the prepackaged software firms (Adobe, Autodesk, Computer Associates, Microsoft, Oracle, Sybase, and Synopsys), and 541 for the system-design and processing firms (EDS, IBM, Mentor Graphics, Novell, and Unisys).

Figure 3: Patent Applications per Billion Dollars in Sales
(by Sector) (1990–2001)

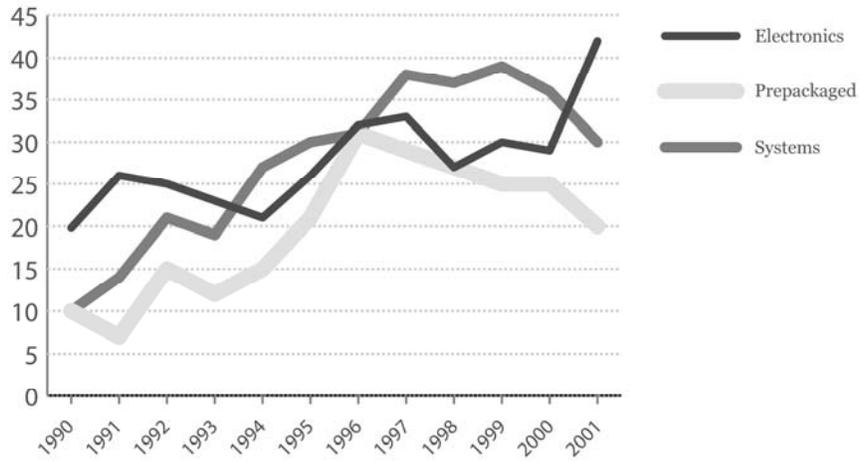


Figure 4: Patent Applications per Billion Dollars in R&D
(by Sector) (1990–2001)

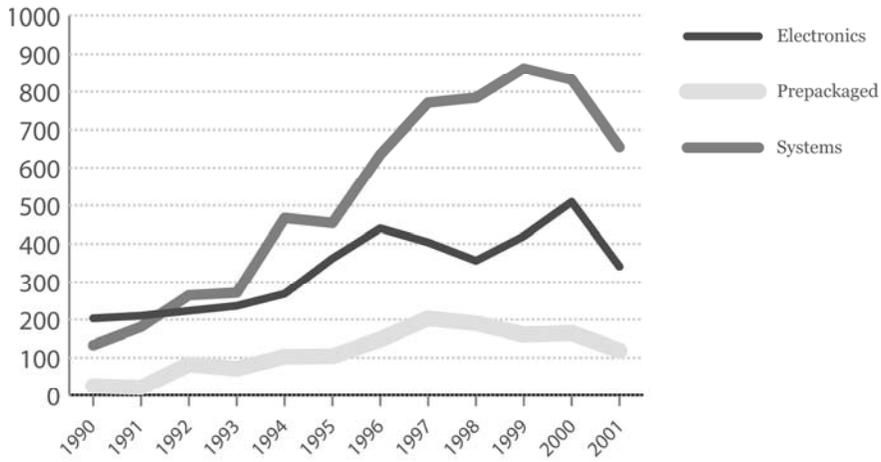


Figure 5: Patent Applications per Billion Dollars in Sales
(by Firm) (1990–2001)

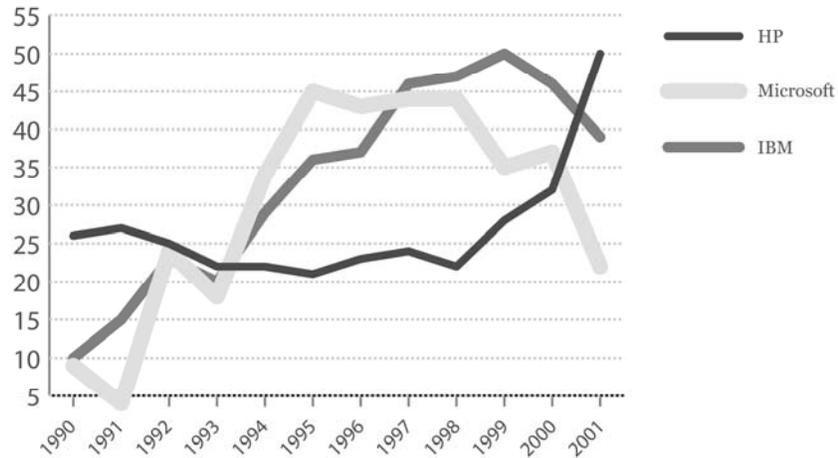
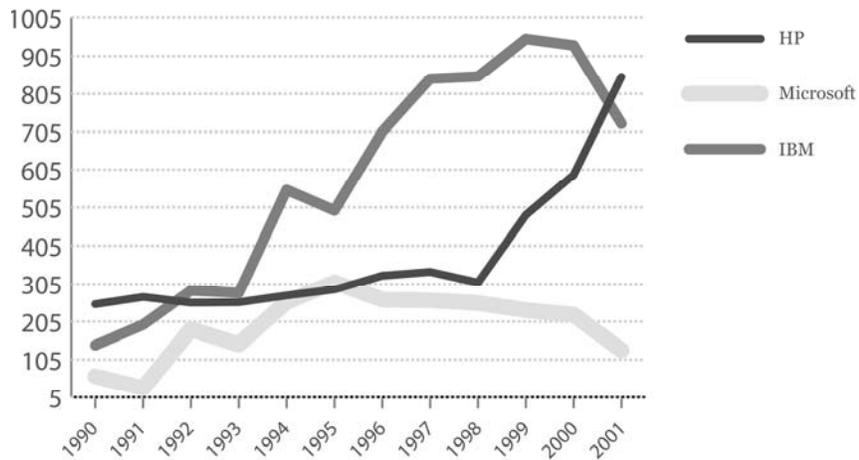


Figure 6: Patent Applications per Billion Dollars in R&D
(by Firm) (1990–2001)



The data on patenting as a function of R&D is particularly illuminating, given the industry focus on the ratio of patenting to R&D dollars.⁵⁷ Indeed, some researchers have become concerned that patents might be substituting

57. See Randall Stross, *Why Bill Gates Wants 3,000 New Patents*, N.Y. TIMES, July 31, 2005, at BU3 (attributing Microsoft's conclusion that it was underpatenting to its comparatively low ratio of patents to R&D dollars).

for research expenditures.⁵⁸ Others, however, have pointed out that patenting and R&D affect one another and are driven by similar factors.⁵⁹

What we do know (as illustrated by the descriptive data in Figures 2, 4, and 6 above) is that the propensity to patent in the industry increased rapidly during the early part of the 1990s. It is evident, however, that the rapid upward trend ended quite some time ago, perhaps by 1997. Indeed, if the comparative charts suggest anything, it is that R&D expenditures as a function of sales have grown more rapidly in the prepackaged software sector than in the others.

In general, however, none of this tells us whether firms are innovating more or less, or whether the patents are of a higher or lower quality. Rather, these charts suggest that the firms in the industry, for the reasons discussed above, were steadily instituting processes to protect more of their technologies and protecting things that might be less “valuable” or less central to their existing products. Thus, the shift in propensity to patent might reflect a conscious decision to protect more of the things that the firm has developed that are not yet marketed (and thus protected through secrecy). In short, whereas firms in the 1980s patented their most fundamental and crucial technologies, the modern software firm with a patenting portfolio is likely to patent as a matter of routine.⁶⁰

III. Explaining the Pattern of Patents in the Modern Software Industry

A. Introduction

Turning from history to the modern software industry, what we see now is a complex pattern of software patenting influenced by features of the firm. Although the frequency of patenting is a major topic of public debate, little work has been done to explain the pattern of patenting.⁶¹ To be sure, the

58. James Bessen & Robert M. Hunt, *An Empirical Look at Software Patents* 38–41 (Fed. Reserve Bank of Phila., Working Paper No. 03-17/R, 2004), available at <http://www.researchoninnovation.org/swpat.pdf> (arguing that software patents substitute for R&D spending); see also Robert M. Hunt, *When Do More Patents Reduce R&D?*, 96 AM. ECON. REV. 87, 90 (2006) (“[F]irms that concentrated on obtaining software patents experienced a . . . significant decline in their R&D intensity, relative to other firms.”). Bessen and Hunt published a portion of this article in James Bessen & Robert M. Hunt, *An Empirical Look at Software Patents*, 16 J. ECON. & MGMT. STRATEGY 157 (2007). Two of us discuss some of the problems with their approach in Allison & Mann, *supra* note 7.

59. Ashish Arora, Marco Ceccagnoli & Wesley M. Cohen, *R&D and the Patent Premium* 1 (Nat’l Bureau of Econ. Research, Working Paper No. 9431, 2003), available at <http://papers.nber.org/papers/w9431.pdf>.

60. Along the way, the industry has transitioned from one with a small number of relatively broad “pioneering patents” to one with a large number of narrow patents, which has caused justifiable concern about the transaction costs of licensing.

61. Although the literature provides no definitive theoretical framework for predicting when patents will be useful, an article by Wesley Cohen and his coauthors takes steps toward a general explanation as part of a description of differences between the United States and Japan. Wesley M. Cohen et al., *R&D Spillovers, Patents, and the Incentives to Innovate in Japan and the United*

existing literature does recognize a rough cross-licensing equilibrium among the incumbent firms.⁶² Many of those firms have substantial patent portfolios, but a web of explicit or implicit cross-licensing agreements means that the major incumbents have access to most of the patented technologies in the industry. Thus, those firms compete against each other, for the most part, on product design and marketing. At this point, patent-based market power does not appear to be a significant factor.

If the desire to build portfolios for defensive purposes were the main justification for patents in the industry, however, one would expect portfolios roughly proportionate to litigation exposure. Assuming that the firm's size is a reasonable proxy for litigation exposure, this suggests an easy quantitative inquiry. Specifically, if the defensive portfolio hypothesis is correct, patent portfolios would correlate closely with size, and there would not be a great deal of variation tied to other factors such as market sector or R&D intensity.

Because there are in fact notable differences in patenting practices in different sectors of the software industry,⁶³ we expect that the pattern of patenting will depend not only on size, but also on whether the firm focuses on selling products or services, how devoted the firm is to R&D (conventionally measured by R&D intensity, calculated as $\$R\&D/employee$), whether the firm is primarily a software firm or a hardware/electronics firm, and competitive issues in the specific sector of the software industry in which the firm is located.

To examine those questions, we combined patent data with data about firms in *Software Magazine's* Software 500 from 1998–2002.⁶⁴ Because we

States, 31 RES. POL'Y 1349 (2002). In their view, patents can play two distinct roles: as tools for exclusion (to be exploited through production within the patenting firm), and as tools for licensing (to be exploited through licensing outside the boundary of the patenting firm). *Id.* at 1365. They develop a distinction between “discrete” and “complex” products, finding evidence to support the idea that “complex” product industries in the United States rely more heavily on licensing to permit exploitation outside the boundaries of the firm. *Id.*

62. For a detailed discussion, see Ronald J. Mann, *Do Patents Facilitate Financing in the Software Industry?*, 83 TEXAS L. REV. 961, 990–92 (2005).

63. See Mann & Sager, *supra* note 7, at 198–99 (finding a significant correlation between number of patents and software-industry subsector).

64. The Software 500 ranks the top 500 firms in the software industry each year by software revenue. *The Software 500*, SOFTWARE MAG., June 1999, at 32, 32. *Software Magazine* collects information for the Software 500 from an annual vendor survey, public documents, press releases, SEC filings, and industry analysts. *Id.* Based on interviews within the industry, we have the impression that the survey response rate is quite high. The list appears to be widely regarded as authoritative within the industry. Campbell-Kelly, for example, uses the list pervasively in his comprehensive history of the industry. See CAMPBELL-KELLY, *supra* note 41, *passim*. Among other things, it is considerably more comprehensive than the “Softletter 100,” which is limited to prepackaged software providers and thus generally excludes services firms. See Stewart J.H. Graham & David C. Mowery, *Intellectual Property Protection in the U.S. Software Industry*, in PATENTS IN THE KNOWLEDGE-BASED ECONOMY 219, 232–33 (Wesley M. Cohen & Stephen A. Merrill eds., 2003) (using the trade newsletter “Softletter 100” to identify trends in software patenting).

Because of considerable turnover in the industry, that list includes about 1,000 firms for the five-year period. For each firm, the Software 500 includes several data points of interest, total revenues,

are interested in the characteristics that relate to software patents, we divided the data set of 34,000 patents into software and nonsoftware patents. The methodology was to examine the patents individually to determine whether each patent, properly speaking, should be considered a patent on a software invention.⁶⁵ Using that methodology, about 68% (13,500) of the non-IBM patents and about 55% of the IBM patents (extrapolating from the sample that we examined), qualified as software patents for a blended total of about 62% (21,200) of software patents.⁶⁶ As Table 1 illustrates, the patents were highly concentrated—more than 80% of the firms had not even a single patent, and less than 10% had more than one patent.

total revenues from software-related activities, percent of revenues expended on research and development, number of employees, and percent of revenues generated by the sale of services. Because the purpose of our study is to focus on firms that fairly can be characterized as software firms, we excluded the eighteen firms that did not derive at least 20% of their total revenues from software in any of the five years for which we collected data.

65. Allison examined all of the patents except the patents for IBM and categorized each patent for which *at least one claim element covered data processing* as a software patent. For the 14,000 IBM patents, he read a random sample of 325 patents and extrapolated from that sample. The distinction is a difficult one because there is no specific patent class for software patents. Prior scholars have taken one of two approaches. First, Graham and Mowery look at the portfolios of large prepackaged software firms and develop a set of classes that includes most of their patents. Graham & Mowery, *supra* note 64, at 220. Second, Bessen and Hunt develop a keyword search designed to capture software patents. Bessen & Hunt, *supra* note 58, at 8. Although our approach arguably is more subjective, we believe that the increased accuracy makes it preferable. For a more detailed explanation of our definition of a software patent and what we view as its superiority to other attempts to identify data sets of software patents, see Allison & Mann, *supra* note 7 (manuscript at 8–14).

66. To provide additional data points for robustness checks (as described below), we subsequently collected a set of all of the patents issued to the firms from January 1, 2003, through June 30, 2005 (an additional 20,000 patents), but we did not analyze those patents to determine whether they were software patents or not.

Table 1: Distribution of Patent Portfolios

# of Patents	Software Patents (1998 and 1999)	All Patents (1998–2000)
	# of Obs. (Cum. %)	# of Obs. (Cum. %)
0	596 (85%)	899 (81%)
1	49 (92%)	90 (89%)
2	14 (94%)	30 (91%)
3	5 (94%)	17 (93%)
4	6 (95%)	16 (94%)
5	0 (95%)	3 (95%)
6	1 (95%)	2 (95%)
7	4 (96%)	2 (95%)
8	0 (96%)	3 (95%)
9	1 (96%)	2 (96%)
10 or more	27 (100%)	50 (100%)
Total # Obs.	703	1114

We examined the variation in patenting by constructing a patent production function to identify the factors that might influence the number of patents a firm produces.⁶⁷ Because we are interested in software patents, we estimated two sets of models: one using only software patents and a second using total patents. The sections that follow report our findings on the five explanations discussed above: size, share of revenues from product licensing, R&D intensity, share of revenues from hardware sales, and industry sector.

B. Analysis

1. *Patenting and Size.*—As suggested above, it is natural to expect that patenting would correlate with size to some degree. This might be true because of economies of scale in patenting, it might be true because larger firms are more likely to have matured to the stage where they can develop sophisticated patenting policies, or it might be true because larger firms are more likely to derive value from patents than smaller firms. Or, it might simply relate to litigation exposure, as discussed above.

Tables 2 and 3 summarize our analysis. Table 2 presents the software patent model, and Table 3 presents the total patent model. We report *t*-statistics in parentheses after the coefficient. Given its intuitive appeal, it is

67. Our analysis is similar to that used in 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 (2001). Following Hall & Ziedonis, *supra*, and Jerry Hausman, Bronwyn H. Hall & Zvi Griliches, *Econometric Models for Count Data with an Application to the Patents-R & D Relationship*, 52 ECONOMETRICA 909 (1984), and Bessen & Hunt, *supra* note 58, we estimate our models using both Poisson and negative binomial distributional assumptions.

Similar to previous work, we assume that the number of patents applied for in a year is a function of a firm's R&D spending and other characteristics of the firm. The subscript *i* denotes the firm, and the subscript *t* denotes the year. The number of patents produced by firm *i* at time *t* is denoted by the variable y_{it} . We assume that the number of patents is a function of observable and unobservable factors. The primary estimates in this Article assume that the unobserved component has a Poisson distribution. Under the Poisson distribution assumption the expectation of y_{it} takes the form:

$$\sum(y_{it}) = \exp(x_{it}\beta).$$

The expectation of the model is a function of observed exogenous variables x_{it} and a vector of parameters β . The parameters of the model are estimated using maximum likelihood. We note here an important feature of our analysis. In general, a maximum likelihood model will not be consistent unless the distributional assumption of the model is correct. However, C. Gourieroux, A. Montfort & A. Trognon, *Pseudo Maximum Likelihood Methods: Application to Poisson Models*, 52 ECONOMETRICA 701, 701 (1984) show that if the mean of the above equation is correctly specified, then the estimate of β will be consistent even if the data rejects the Poisson distributional assumption. The standard errors must be corrected to be robust to alternative distributions. This is important because the assumption that the variance of the Poisson model is equal to the mean is restrictive and often (as with the data here) incorrect in practice, typically when the excess of the variance over the mean reflects "overdispersion." We discuss in detail below how we have addressed the problems in matching the distributional assumptions of those models to the characteristics of this data set.

not surprising that size is relevant, measured by $\log(\text{Employee})$.⁶⁸ That variable has a stable sign (positive) and a stable magnitude (slightly more than one in all four models), and is statistically and economically significant in each of the four models. Because the variable is a log transformation of the raw employee data, the coefficient should be interpreted as a constant elasticity. For instance, all other things held constant, the coefficient of 1.17 in Column 1 of Table 2 on $\log(\text{Employee})$ implies that a 10.0% increase in the number of employees causes an 11.7% increase in the number of software patents.⁶⁹ Because this coefficient is slightly more than one, it suggests that returns to scale in number of employees are approximately constant in the software industry. In other words, other things held equal, firms patent in proportion to their size, so that if the number of employees is doubled, we would expect the firm to produce slightly more than twice the number of patents.

Table 2: Propensity to Produce Software Patents

	(1) Poisson	(2) Negative Binomial	(3) Poisson	(4) Negative Binomial
Log(R&D/Employee)	0.889 (3.83)	0.828 (3.28)	0.599 (2.56)	0.934 (3.44)
Log(Employee)	1.171 (14.86)	1.094 (13.84)	1.138 (12.07)	1.061 (12.09)
Services	-0.023 -(2.87)	-0.040 -(5.58)	-0.015 -(2.11)	-0.020 -(2.43)
Fraction Software Sales	-0.009 -(1.78)	-0.002 -(0.25)	-0.008 -(2.43)	-0.005 -(0.65)
Zero R&D	-4.770 -(5.11)	-4.259 -(2.33)	-4.020 -(5.07)	-4.907 -(2.38)
Year 1999	0.009 (0.04)	-0.096 -(0.31)	-0.136 -(0.54)	-0.225 -(0.70)
Constant	-3.788 -(2.42)	-3.555 -(2.84)	1.349 -(0.23)	-3.797 -(2.74)
Alpha		4.458 (6.25)		2.921 (5.67)
Sector Fixed Effects	No	No	Yes	Yes
# Observations	703	703	612	612
# Firms	511	511	445	445
log-likelihood	-1049	-500.2	-749.8	-448.7

68. Because of the skewed distribution, we regress $\log(\text{Employee})$ rather than the raw data on number of employees.

69. This result is slightly higher, but comparable to other results found in the literature, including Hall & Ziedonis's calculation of a coefficient of 0.989 in the semiconductor industry. See Hall & Ziedonis, *supra* note 67, at 116 tbl.1. It also is slightly higher than Bessen and Hunt's calculation of a coefficient of 0.880 in the production of software patents by firms that are for the most part outside the software industry. See Bessen & Hunt, *supra* note 58, at 50 tbl.5.

Table 3: Propensity to Produce Patents

	(1) Poisson	(2) Negative Binomial	(3) Poisson	(4) Negative Binomial
Log(R&D/Employee)	0.614 (2.31)	0.915 (4.81)	0.681 (2.70)	0.800 (4.53)
Log(Employee)	1.071 (13.88)	1.046 (13.79)	1.143 (14.43)	1.055 (14.41)
Services	-0.026 -(3.80)	-0.033 -(5.27)	-0.015 -(2.28)	-0.025 -(4.63)
Fraction Software Sales	-0.008 -(2.13)	-0.004 -(0.78)	-0.008 -(1.60)	-0.004 -(0.94)
Zero R&D	-4.219 -(4.08)	-5.157 -(6.05)	-4.001 -(3.89)	-4.148 -(4.85)
Year 1999	0.442 (1.49)	0.479 (1.53)	0.527 (2.26)	0.443 (1.87)
Year 2000	-0.121 -(0.38)	-0.179 -(0.53)	0.116 (0.52)	-0.221 -(0.91)
Constant	-3.770 -(3.69)	-2.869 -(3.67)	-5.376 -(4.33)	-4.333 -(4.09)
Alpha		4.187 (5.89)		3.135 (5.89)
Sector Fixed Effects	No	No	Yes	Yes
# Observations	1105	1105	1029	1029
# Firms	642	642	589	589
log-likelihood	-1975	-905.2	-1427	-830

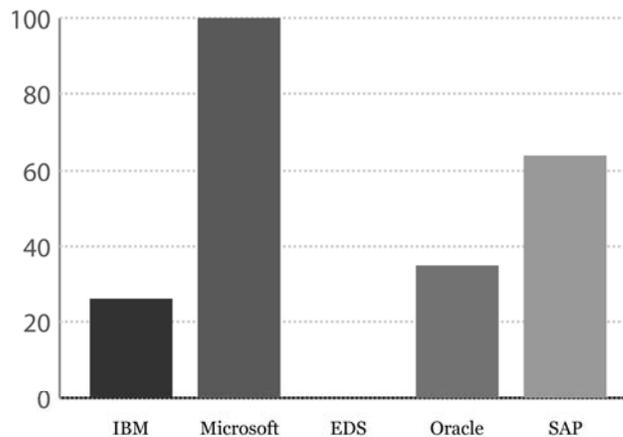
The size of the coefficient sheds light on the relation between size and patenting practices. For example, if the acquisition of patents were substantially more attractive for larger firms than for smaller firms, the coefficient would be substantially greater than one.⁷⁰ If the acquisition of patents were substantially more attractive for smaller firms than for larger firms, the coefficient would be substantially less than one because the size of the portfolio would not increase as quickly as the size of the firm. Because the coefficient is so close to one, it seems likely that the other variables in our model have captured the size-related reasons why patents have different utilities for firms.

2. *Products and Services.*—The most promising explanation for the variation in patenting practices, drawn from the management literature,

70. The absence of a large coefficient here seems to be in tension with the predictions of Gideon Parchomovsky and R. Polk Wagner about the relative importance of patenting for large firms. See Gideon Parchomovsky & R. Polk Wagner, *Patent Portfolios*, 154 U. PA. L. REV. 1, 55 (2005) (“For large firms, a major driver of patenting behavior is the need to create substantial patent portfolios—independent of the expected values of any particular individual patents.”).

focuses on a continuum from products firms to services firms.⁷¹ Firms that sell software products generally have higher operating margins, higher growth rates, and less stable market shares, whereas services firms generally have lower operating margins and lower growth rates, but can more readily establish stable market positions.⁷² Thus, a products firm such as Microsoft will have high volume sales of noncustomized products that customers can use “off the shelf” with little or no assistance, and a typical services firm such as EDS will generate revenues by helping firms to install, design, and maintain software. The products model is relatively more effective for venture-backed start-ups than the services model. Because products firms can “scale,” i.e., achieve economies of scale, more easily than services firms, successful products firms are more likely to produce the high returns venture capital investors seek. There also are a large number of hybrid firms like Oracle. Some of those firms began by attempting to sell products, but later were forced by market conditions to provide increasing levels of customization, thus degrading their ability to sell high volumes of a pure high-margin product. To get a sense for the variation, Figure 7 displays the differing shares of revenues attributable to product licensing for five of the largest software firms.⁷³

Figure 7: Products Revenue Share for Leading Software Firms in 2002



71. See MICHAEL A. CUSUMANO, *THE BUSINESS OF SOFTWARE* 25–26 (2004) (describing a products firm as one that makes the majority of its revenues by volume sales of software packages, while services firms customize products for each customer and provide training, maintenance, and technical support).

72. See *id.*

73. Although accounting practices might differ slightly, product licensing encompasses the fees generated from software products and excludes services revenue related to maintenance, support, consulting, and the like.

Given the obvious difference in appropriation strategies, the products–services distinction provides a useful lens for exploring the apparent disparity of patenting practices in the industry. Patents seem likely to be a relatively more effective tool for protecting innovation in products than in services. To the extent a firm can provide a unique level of skilled services, it may be feasible to maintain much of the differentiating knowledge in a tacit form, bound up with the skills of the individual employees. Conversely, a products firm that sends its product out into the marketplace in many instances will be vulnerable to appropriation by competitors.⁷⁴ If so, a patent that permits a firm to fence out competitors will have considerably more value to a products firm than to a services firm. This, in turn, suggests the hypothesis that products firms, because their technology is more difficult to protect than the technology of services firms, will produce more patents than services firms, all other things being equal.

Because the *Services* variable is a fraction of software revenues, and because our hypothesis is that the devotion of the firm to a products model should relate positively to the firm's propensity to patent innovations related to software, the results in Table 2 should provide the clearest test of our primary hypothesis, with Table 3 primarily relevant as a robustness check. In Table 2, the *Services* variable is negative and significantly related to the dependent variable in all of the different runs. The impact of the *Services* variable on the number of patents also appears to be economically significant. For example, referring to the base (Poisson) model in Column 1, the coefficient suggests that a 1.0% *increase* in the percentage of software sales coming from services (e.g., percentage of sales increasing from 50.0% to 51.0%), implies a 2.3% *decrease* in the number of patents produced.⁷⁵ A more extreme result suggests that the magnitude of the *Services* variable is also economically significant. A firm that derives all its revenues from products (e.g., *Service* = 0%) is expected to produce 230% more patents than a firm entirely devoted to providing services (e.g., *Service* = 100%).

These findings are robust. For example, the sign and general magnitude of the coefficient were stable in a model (reported in Column 2 of Table 2)

74. See Mann, *supra* note 62, at 985 (noting that many companies cannot reap the rewards of excluding competitors unless they can survive to a stage where they are profiting from their own exploitation of a product); Pamela Samuelson et al., *A Manifesto Concerning the Legal Protection of Computer Programs*, 94 COLUM. L. REV. 2308, 2333–39 (1994) (explaining that much of the value of software is in its surface design that is “prominently displayed by the program in operation,” and “[a]ny product that bears a large quantum of its know-how on its face is vulnerable to rapid imitative copying because this know-how cannot be kept secret”).

75. Although the goodness-of-fit test rejects the Poisson distributional assumption, we nevertheless report the results of this analysis, following prior statistical practice. See Gouriou, Montfort & Trognon, *supra* note 67. As recommended there, we use heteroscedastic-consistent standard errors to calculate t-statistics. The goodness of fit test is based on the deviance statistic. The standard error estimates used to compute the t-statistics are robust to heteroscedasticity and misspecification of the distribution. To account for the multiple observations of some firms and the consequent possibility of autocorrelation, the standard errors are clustered.

using a negative binomial distributional assumption instead of our base Poisson assumption.⁷⁶ The parallel runs using total patents as the dependent variable, reported in Table 3, are similar.⁷⁷ Most importantly (as summarized in Columns 3 and 4 of Table 2), we also estimated a series of models that include sector-specific fixed effects to control for differences in the propensity to patent across different sectors in the software industry.⁷⁸ Inclusion of the sector-fixed effects is important for two reasons.⁷⁹ First, the estimates in Columns 1 and 2 do not indicate whether the *Services* variable is capturing different propensities to patent that relate to differences between sectors, or whether the product–services distinction is also important within sectors. Inclusion of the sector-specific fixed effects along with the *Services* variable focuses the test of the *Services* variable. Specifically, this model shows that the products–services distinction is important within sectors.

The results of the Poisson model and the negative binomial model both indicate that the *Services* variable continues to be negative as well as statistically and economically significant. What this suggests is that the devotion of a firm to a products or services model is important, even within a particular sector. Thus, the data do not suggest simply that some sectors of the industry rely more on products and some more on services or that those differences can explain levels of patenting activity. Rather, the data suggest important differences along the products–services continuum, even within particular sectors. To be sure, the magnitude of the coefficients on the *Services* variable does drop considerably (from 0.023 and 0.040 to 0.015 and 0.020, respectively), but this merely suggests that sector differences capture a portion of the difference in patenting activity.⁸⁰

76. We use a negative binomial model because the goodness of fit test suggested that our data is overdispersed. The negative binomial model is consistent only if the true distribution is negative binomial; however, if this is the true specification, then the estimate is more efficient than the Poisson model. Referring to Column 2 of Table 2, the parameter alpha is the overdispersion parameter. The high t-statistic, indicating that alpha is significantly different from zero, indicates that overdispersion remains even in the negative binomial model.

77. This has the advantage of having more data points (because we can use the additional 20,000 patents from 2003–2005), but it has the disadvantage that we must analyze total patents rather than software patents (because we have not divided the later patents into software and nonsoftware patents). In any event, those runs produced results and coefficients similar to those set out in Table 2.

78. We test the joint statistical significance of the sector-specific fixed effects by using a likelihood ratio test based on the selected sample. For both models, we reject the null hypothesis that the sector-specific fixed effects have no explanatory power at the 95% confidence level.

79. Inclusion of sector-specific fixed effects necessitates dropping several observations from the analysis. Sectors that have no patents are excluded from the analysis because the sector-specific fixed effects entirely explain the number of patents in those sectors. In addition, the sector category marked “other” is also excluded because it does not represent any particular sector. The sector-specific-fixed-effect estimates are based on the remaining 612 observations from the 445 remaining firms.

80. In separate runs that we do not report here in detail, we attempted to analyze the differences in patent production functions for products and services firms. See Hall & Ziedonis, *supra* note 67, at 119 (using similar analysis for semiconductor firms). Although our analysis strongly rejects the

We emphasize the ambiguity of causation in this finding. On the one hand, it might well be that firms have a higher propensity to patent because they are products firms, either because of the greater ability of those patents to protect innovation in products or because of the greater need to protect innovation that is disclosed through the distribution of products. Conversely, it might well be that a patenting culture in a firm's early days could contribute to its survival as a products firm. Referring back to Figures 1 and 2, the most dominant products firms (Microsoft and Adobe, with 100% and 99% products revenue shares) were among the earliest prepackaged software firms to start patenting, while the three late patentees shown in those figures survive today as the most prominent hybrid firm (Oracle, with a 35% products revenue share) and as two of the largest services firms (Autodesk and Computer Associates, with 0% products revenue shares). It is at least possible to believe that the late patenting strategies of those firms undermined their competitive position in products markets and forced their retreat into the realm of nonproducts firms.

3. *Patenting and R&D Intensity.*—The next possibility is that a firm's R&D intensity affects its production of patents. Specifically, assuming that the firm has the same number of employees, the same share of products–services revenues, and is in the same sector in the industry, will the number of patents relate to the intensity of R&D investment (measured by dollars of R&D investment per employee)? The discussion in Part II regarding the increase in the number of patents as a function of R&D strongly suggests that R&D intensity is important. Not surprisingly, Tables 2 and 3 suggest that R&D intensity does explain an important portion of the variation in patenting rates.

Like the previous variables, R&D intensity has a stable sign (positive) and a coefficient that is both statistically and economically significant. Specifically, the elasticity of R&D intensity on patenting is 0.89. Again, this is similar to the results found by Bessen and Hunt of 1.01.⁸¹ However, these estimates are much larger than results in the semiconductor industry of 0.18

possibility that the patent production functions are the same, it is not easy to interpret our findings about how they differ. For example, we found that the elasticity of software patent production with respect to R&D intensity is greater for products firms and services firms and that the elasticity of software patent production with respect to employees is greater for services firms than for products firms. On the other hand, looking at the elasticity of total patent production, we find that services firms have a greater elasticity for both R&D intensity and employees than products firms. Neither of those differences, however, is significant. Our tentative inclination is to accept the results related to software patent production, concluding that the greater heterogeneity in our data set on total patents makes it less useful for analyzing the factors related to patent production.

81. Bessen & Hunt, *supra* note 58, at 19. Bessen and Hunt find different results when accounting for firm-level heterogeneity using fixed effects. *Id.* However, their fixed-effect estimation excludes firms with zero patents. *Id.* Such firms include a majority of firms in this Article and in the Bessen and Hunt article. Therefore, we compare the basic Poisson regressions as these include all firms and are less prone to sample-selection bias.

found by Hall and Ziedonis.⁸² Generally, this suggests that although the effects of size in the software industry are about the same as those in the semiconductor industry, the effect of R&D intensity on software patenting is quite a bit greater than its effect on semiconductor patenting.

4. *Patenting and Hardware Revenues.*—Another possibility we attempted to test is that hardware or systems firms will have different patenting strategies than pure software firms. This hypothesis is drawn from the common suggestion in interviews with software executives that the typical hardware firm has a culture that is different from that of the typical software firm: the typical hardware-firm culture emphasizes institutions that facilitate patenting; the typical software-firm culture resists those institutions.⁸³ Because the hypothesis here relates to the overall patenting philosophy of the firm, the hypothesis is tested more directly with the data on total patents in Table 3.

The results here are markedly less robust than for the other variables. The relevant variable for this question is *Fraction Software Sales*. As Table 3 displays, the results range from marginal statistical significance (in the Poisson model) to no significance in the other models. The coefficient is also quite small, though usually with the negative sign that the hypothesis suggests (indicating that firms with higher shares of revenues from software rather than other lines of business are likely to have fewer patents than firms with lower shares of revenue from software sales).⁸⁴

What is most interesting about those results is the small coefficient, which suggests that any distinction between the patenting practices of pure software firms and firms with substantial nonsoftware revenues is slight. In light of the history summarized in Part II, this suggests that by the time our data were collected, the cultural resistance to patenting in the software industry had lost much of its force. Even if there is a slight lingering distinction, patenting already had become as routine for software firms as it had long been for hardware firms.

5. *Patenting and Software Sectors.*—The final variable we considered was the relation between industry sectors and patenting propensities. As discussed above, differences among the widely heterogeneous sectors in the software industry may explain some of the differences in patenting practices between firms. The question remains, in light of the sections above, whether our more general variables capture the reasons for patenting variations

82. Hall & Ziedonis, *supra* note 67, at 116 tbl.1.

83. See Mann, *supra* note 62, at 982–85 (discussing concerns that an emphasis on patenting will divert a firm's focus from product development).

84. We have also run a number of robustness checks. These include not only the Table 2 models analyzing software patenting rates (rather than total patenting rates), but also checks that include a number of outliers with very large portfolios, a random-effect Poisson estimate with sector-specific fixed effects, and firm-level fixed effects. Those results are similar to those we report in the text.

between sectors. The problem in using the “Software 500” sector designations is that *Software Magazine*, during the period for which we collected data, used more than 100 different sector designations, many of which include very few firms. Accordingly, we constructed a modified set of sectoral designations, which consolidates the Software 500’s designations into “only” 36 sectors.⁸⁵ Table 4 below lists the different sectors and provides basic descriptive statistics for the firms in each sector.

Table 4: Software Sector Descriptive Statistics (1998 and 1999)

	R&D	Empl. (1000s)	R&D per Emp	Services	SW Patents	SW Patents	SW Patents	SW Patents	Count of Obs.	Count of Firms
	Median	Median	Median	Median	Mean	Median	75%	90%		
Application Dev't/Prnt	6.95	220	0.032	22	0.23	0	0	1	61	42
Application Serv. Prov.	1.39	89.5	0.017	26	1.75	0	3.5	7	4	4
Asset/Technol. Mgmt.	7.38	421.5	0.027	38.5	0.00	0	0	0	12	7
Business Intelligence	12.83	446	0.029	28	0.37	0	1	1	27	20
Bus. Process Mgmt.	21.51	525	0.035	54	0.33	0	1	1	3	3
Computer Ass'd Draft'g	5.72	283	0.020	32	1.57	0	0	11	7	5
Content/Doc. Mgmt.	8.71	188.5	0.031	18	0.18	0	0	0	28	22
Collab./Proj. Mgmt.	10.40	376	0.029	38	0.00	0	0	0	4	2
Cust. Ref'nship Mgmt.	5.84	206	0.031	35	0.32	0	0	0	41	32
Database	18.84	505.5	0.032	25	9.69	0	2	62	16	12
Disaster Recovery	0.84	38	0.022	27	0.00	0	0	0	1	1
Data Warehouse	298.02	5679	0.044	12	15.29	0	49	57	7	5
Enterprise Appl. Integr'n	6.48	261	0.030	30.5	0.06	0	0	0	36	26
E-Business Applications	7.27	217.5	0.027	31	0.25	0	0	1	44	31
E-Commerce	13.57	195	0.032	13	0.00	0	0	0	5	5
E-Learning	34.18	1500	0.023	26	0.00	0	0	0	3	3
Enterprise Res. Planning	11.25	522.5	0.023	40.5	0.10	0	0	0	62	44
Financial Applications	8.29	270	0.027	32	0.02	0	0	0	42	29
Geogr. Info. Systems	18.05	420	0.029	9	6.00	0	9	32	7	5
Healthcare	3.33	106	0.020	22	0.00	0	0	0	9	6
Human Resources	3.05	31	0.022	26.5	0.00	0	0	0	16	10
Infrastructure	7.85	250	0.037	23	1.33	0	0	2	55	39
IT Sourcing	5.73	300	0.021	53	40.15	0	0	138	13	9
Marketing Automation	2.23	78	0.024	23	0.00	0	0	0	5	3
Middleware	5.67	200	0.029	17	0.42	0	1	2	19	16
Operating Systems	25.71	641	0.039	14.5	43.14	1	2	271	14	10
Portal Tools	3.32	151.5	0.026	34.5	0.00	0	0	0	8	7
Publishing/Graphics	9.12	300	0.034	0	3.20	1	4	11	5	5
Retail Applications	27.74	1068	0.026	74	0.00	0	0	0	1	1
Supply Chain	8.25	253	0.030	42.5	0.63	0	0	1	54	38
Security	12.11	450	0.032	13.5	1.50	0	1.5	6.5	20	15
Sales Force Automation	7.21	381	0.039	39.5	0.00	0	0	0	4	4
System Integration Servs.	9.53	2240	0.011	49	65.00	0	35.5	361	16	10
Storage Management	3.79	135	0.032	11	7.14	0	4	43	7	5
Vertical Indus. Appl.	3.57	273.5	0.015	39.5	1.60	0	0	0	20	15
Wireless/Mobile	3.33	119.5	0.033	37	0.25	0	0.5	1	4	3
Other	6.04	164	0.031	20	1.65	0	0	2	23	17
Total # of Firms:		511								
Total # of Observations:		703								

The variation in the median of size and service revenue underscores the heterogeneity of the sectors. For example, the median data-warehousing firm has about 5,000 employees, while the median disaster-recovery firm has only 38. Similarly, the typical data-warehousing firm derives only 12% of its revenues from services, while the median retail-applications firm derives 74% of its revenues from services.

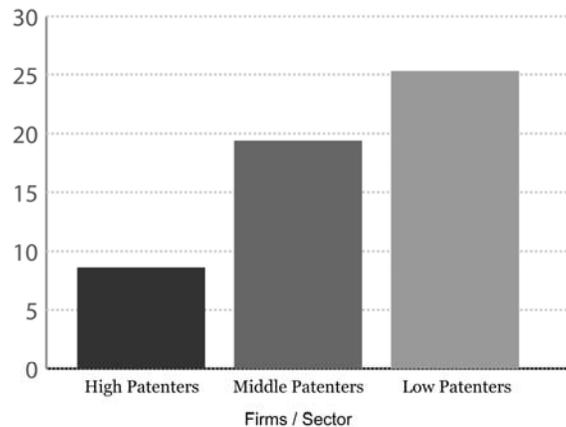
Of particular import for our work is the variation in patenting practices, with quite a number of reasonably well-populated sectors entirely devoid of patents (human-resources software, for example), and others in which

85. A good deal of our consolidation reflected collapsing different designations used from year to year for similar firms.

substantial portfolios exist (operating-systems and systems-integration services, for example, with an average of more than forty patents per firm). Table 5 presents a more rigorous examination of that question—a sector-fixed effect analysis designed to illustrate the particular effects on patenting propensity of each of the sectors. As you would expect given the discussion above, Table 5 illustrates stark differences among sectors that are not captured by the other variables.

Perhaps the most interesting point from that table is the apparent relation between concentration in a particular sector and patenting propensity. As Figure 8 illustrates, the sectors with the highest propensities to patent have fewer firms per sector than the sectors with moderate or low propensities to patent. It is difficult to be sure why industry concentration would relate to patenting propensity. One possibility suggested by Cockburn and MacGarvie is that the presence of substantial patent portfolios may deter further entry into the sector.⁸⁶ Another possibility is that weaker firms disappear as sectors mature. If substantial portfolios are a feature of relatively mature firms, we would expect mature sectors to have a smaller number of firms with greater average rates of patenting. The breakdown of sectors in Table 5 provides some support for this possibility.

Figure 8: Patenting Rates and Sector Concentration



86. See Cockburn & MacGarvie, *supra* note 7, at 33 (“Controlling for the characteristics of the firm and market, we find that software firms are less likely to enter product markets in which there are more patents.”). One problem with that explanation, at least with respect to Cockburn and MacGarvie’s data, is that they analyze entry in any given year as a function of existing patent portfolios. But most venture-backed software start-ups do not obtain patents until after several years of operation. Accordingly, a sector in which several firms already have strong portfolios is likely to be a sector of relatively mature technology. It should be no surprise that the rate of entry will slow in such a sector, but it is just as likely attributable to the head-start and first-mover advantages of the existing firms as it is to the exclusive force of the patents held by the existing firms.

Table 5: Sector Fixed-Effect Analysis

Software Sector		# Firms	# Obs.	Poisson Model			Neg. Binomial		
				Fixed Effect	S.E.	Rank	Fixed Effect	S.E.	Rank
VA	Vertical Indus. Appl.	15	20	1.925	(0.82)	1	0.841	(0.85)	12
ASP	Application Serv. Prov.	4	4	1.883	(0.45)	2	1.464	(0.68)	2
GIS	Geogr. Info. Systems	5	7	1.607	(0.69)	3	1.288	(0.81)	5
OS	Operating Systems	10	14	1.591	(0.75)	4	1.071	(0.65)	4
PU	Publishing/Graphics	5	5	1.473	(0.58)	5	1.435	(0.79)	3
SEC	Security	15	20	1.392	(0.77)	6	1.492	(0.94)	6
DB	Database	12	16	1.215	(0.42)	7	0.785	(0.68)	10
WVM	Wireless/Mobile	3	4	1.202	(1.24)	8	1.686	(1.22)	8
SC	Supply Chain	38	54	1.159	(0.70)	9	0.435	(0.67)	17
CAD	Computer Ass'd Draft'g	5	7	1.115	(0.74)	10	0.636	(0.82)	16
CRM	Cust. Rel'nship Mgmt.	32	41	1.105	(0.74)	11	0.651	(0.69)	14
ITS	IT Sourcing	9	13	1.030	(0.65)	12	0.816	(0.70)	9
SIS	System Integration Servs.	10	16	0.856	(0.73)	13	1.123	(0.77)	7
SM	Storage Management	5	7	0.747	(0.72)	14	3.518	(1.20)	1
MW	Middleware	16	19	0.686	(0.51)	15	0.940	(0.85)	11
BI	Business Intelligence	20	27	0.407	(0.58)	16	0.665	(0.73)	15
INF	Infrastructure	39	55	0.391	(0.73)	17	0.623	(0.64)	13
DW	Data Warehouse	5	7	0.378	(0.61)	18	0.596	(0.92)	18
BPM	Bus. Process Mgmt.	3	3	0.369	(0.47)	19	0.128	(0.68)	21
CDM	Content/Doc. Mgmt.	22	28	0.055	(0.95)	20	0.253	(1.06)	20
AD	Application Dev'l'pm't	42	61	0.000	-	21	0.000	-	22
EAI	Enterprise Appl. Integr'n	26	36	-0.671	(0.84)	22	-0.576	(1.00)	23
EB	E-Business Applications	31	44	-0.852	(1.09)	23	0.472	(0.78)	19
ERP	Enterprise Res. Planning	44	62	-1.409	(0.72)	24	-0.898	(0.91)	24
FI	Financial Applications	29	42	-2.258	(1.14)	25	-1.930	(1.41)	25

Fitting this together, three points warrant emphasis. First, although patenting does relate to the size of the firm, the pattern is complex, with other variables explaining important parts of the picture. Second, the variables that are most successful in explaining patenting variations are the variables that explain the firm's particular niche within the software industry—the distinction between products and services is central, but the extent to which a firm has nonsoftware business lines is not important. Third, although we have not emphasized it above, it is interesting that the results in Table 2 are so similar to the results in Table 3. Given the common anecdotal impression that software patents can be much less effective at appropriating the value of innovation than hardware patents,⁸⁷ we would have expected the patent production functions for software patents and total patents to differ substantially. The similarity of those functions suggests, again, that the use of software patents is converging rapidly with the use of patents in adjacent sectors.

IV. The Role of Patents in Software Development

A complete picture of the software industry cannot be limited to incumbent firms. As others have recognized, the industry experiences high rates of new entry and turnover among firms of all sizes.⁸⁸ Much of the reason for this phenomenon is that a great deal of the new technology in the industry is developed not by incumbent firms in the first instance, but rather by one of three development channels that are distinct from the incumbent firms: venture-backed firms, open-source development, and independent inventors.⁸⁹ As they do for the incumbent firms, patents play a distinct role in the success of firms from each of those channels.

A. *The Venture-Backed Start-up Channel*

The first and most prominent channel is the venture-backed start-up channel.⁹⁰ In this channel, venture capital firms serve as investment intermediaries, providing capital and management expertise to young firms seeking to make their way into the industry.⁹¹ This channel, of course, has

87. See Mann, *supra* note 62, at 980 n.102 (presenting anecdotal evidence that software executives view software patents as generally easier to work around and less useful than hardware patents).

88. See Merges, *supra* note 7, at 7 (finding that turnover rates in the software industry are comparably higher than many other industries). For a quantitative analysis, see Cockburn & MacGarvie, *supra* note 7, at 16–17, 49 fig.2 (describing and plotting the turnover rates in software markets).

89. The channels are not mutually exclusive. For example, there are a number of open-source venture-backed start-ups, and smaller venture-backed start-ups may resemble independent inventors in many respects. See Mann, *supra* note 20, at 13 (finding more than 100 open-source firms in the United States in which there has been venture capital investment).

90. This subpart draws heavily on Mann & Sager, *supra* note 7.

91. *Id.* at 193.

produced many of the most prominent success stories, with Google providing the most salient recent example.⁹² As mentioned in Part III, venture financing tends to favor products firms, primarily because successful products firms are much more capable of achieving economies of scale (“scaling”) quickly than services firms.⁹³ Because the quick ability to scale relates closely to the ability of venture capitalists to obtain the return they seek on their investments, this model tends to work much better for products firms.

Patents do play an important role for start-up firms. As one of us has explained previously, patents provide little benefit to the early stage prerevenue start-up firm.⁹⁴ But as the firm matures and begins to develop revenue streams, patents become increasingly important.⁹⁵ The reason can be that the firm needs the patents to prevent larger firms from copying its products. The reason also can be that the patents will be important to investors as the firm’s financing needs increase. Or it might be that the patent signals something about the firm’s sophistication or management acumen. Whatever the reason, however, interviews with investors and entrepreneurs strongly suggest that patents can be important for venture-backed software start-ups.⁹⁶ The perspective is not unanimous. Many, if not most, investors recognize the limited value that patents have for appropriating the value of a software innovation, and thus, they worry about how their portfolio firms will defend a market share even if their firms can develop a significant product.⁹⁷

That perspective is buttressed by the available data about the role of patents in venture-backed start-ups. Although only about 25% of venture-backed firms obtain patents,⁹⁸ there is a close relation between the acquisition

92. See JOHN BATTELLE, *THE SEARCH: HOW GOOGLE AND ITS RIVALS REWROTE THE RULES OF BUSINESS AND TRANSFORMED OUR CULTURE* 89 (2005) (recounting how Google obtained millions of dollars in venture capital funds).

93. For the same reason, computer and peripheral firms are not as readily suited to venture capital investment. For example, the PricewaterhouseCoopers National Venture Capital Association *MoneyTree Report* lists 869 software investments for \$4.8 billion for 2005. See PricewaterhouseCoopers & National Venture Capital Association, *MoneyTree Report*, <http://www.pwcmoneytree.com/moneytree/nav.jsp?page=historical> (select “Software” in the “Select Industry” drop-down menu). But the report shows only sixty-one investments in computer and peripheral firms, which total only \$500 million for the same year. See *id.* (select “Computer and Peripherals” in the “Select Industry” drop-down menu).

94. See Mann, *supra* note 62, at 981 (summarizing findings of why developing patents are not so effective in the early stages of a firm).

95. See Mann & Sager, *supra* note 7, at 202 (“[There is] some support for the hypothesis that the value of patents for software startups first becomes significant as they reach the stage at which they begin to generate revenues.”).

96. Mann, *supra* note 62, at 981–82.

97. *Id.* at 978–79.

98. Mann & Sager, *supra* note 7, at 205. The share of firms with patents in this venture-backed data set is higher than the share of firms with patents in the Software 500 data set described in Part III. This is true, presumably, because the venture-backed data set includes a smaller share of services firms. See *id.* (noting that products firms are much more common in the venture-backed data set).

of patents and the progress of firms through the venture capital cycle. Thus, for example, firms with patents are likely to obtain more financing, and they are more likely to succeed.⁹⁹ In general, the relevance of patents to mature and successful portfolio firms is consistent with the discussion at the end of Part II. As these firms mature, patenting becomes a routine part of the firm's operations, just as it has been for many software incumbents for the last decade.

For our purposes, the exit strategy is what is most important about the venture-backed start-up channel. Generally, the venture-backed start-up that develops a successful product will exit from its start-up status in one of two ways. First, it might obtain sufficient funds (generally from public investors) to become a large firm, ascending to the ranks of the incumbent firms in the industry (like Google).¹⁰⁰ Alternatively (perhaps much more commonly), it might sell its technology (normally through a sale of the entire firm) to one of the large incumbent firms.¹⁰¹

What is most unlikely to happen is litigation—rare is the start-up firm that exploits its technology through patent litigation against a large incumbent firm.¹⁰² Although economic theory suggests that it often is difficult for one firm to transfer valuable information to another (Arrow's information paradox¹⁰³), the venture-backed channel avoids that difficulty. Most obviously, the parties in control of mature venture-backed portfolio firms are a small class of venture capitalists, often previously employed at large incumbent firms. Thus, it is easy to expect that those people would have personal relations that would enhance their ability to make credible representations about technology and come to consensual arrangements for acquisition of the start-up. Similarly, the entrepreneurs themselves, to the extent they have any control over the process, are likely to be repeat players, worried about future transactions, and also former employees of incumbent firms themselves. It is easy to see why successful start-ups often are

99. With respect to financing, firms with patents obtain a median of four rounds rather than three, worth \$26 million rather than \$15 million. *Id.* at 199 tbl.4. Moreover, within five years of first financing, 13% of the firms with patents go public and only 4% fail. Conversely, 3% of the firms without patents will have gone public by that point in time and 8% will fail. *Id.* As reported in more detail in Mann and Sager's article, all of those distinctions are statistically significant and stable across a series of checks for robustness. *Id.*

100. *See id.* at 202 & tbl.3 (finding that 5% of the firms in the venture-backed data set had gone public).

101. *See id.* (finding that 10% of the firms in the venture-backed data set had been acquired).

102. *See* Mann, *supra* note 62, at 981–82 (observing that it is unlikely that an early-stage company that has a patent would have the resources to enforce the patent against a large firm). Licensing of technology from start-ups does happen occasionally, though it is rarely the preferred business model of the venture capitalist. *See id.* at 982–83 (relating concerns among investors and developers that an overemphasis on licensing can degrade firm culture by diverting focus from product development). Rather, it is a strategy to which the firm turns when it is unable to execute its chosen path.

103. *See* Ronald J. Mann, *Verification Institutions in Financing Transactions*, 87 *GEO. L.J.* 2225, 2267–68 (1999) (discussing Arrow's information paradox).

acquired by incumbent firms and why litigation to enforce IP against incumbent firms is rarely the chosen strategy.

B. The Open-Source Channel

The open-source channel has gained prominence in recent years as programs like Linux, Apache, and Firefox have been broadly accepted.¹⁰⁴ With its roots in the hacker mythology of the early days of the Internet, the open-source community venerates a decentralized style of software development that is the antithesis of the large bureaucratized incumbent firm.

In the last decade, the open-source community has undergone a profound change. At the same time as its products have become sufficiently successful to gain widespread use in large enterprises, the community's development processes have been adopted by some large incumbent technology firms—a few from the software industry (like IBM and Novell) but mostly from adjacent hardware industries (firms like Intel, HP, and Fujitsu).¹⁰⁵ Thus, the commercially successful open-source programs share the salient characteristic that they benefit from extensive financial support from large incumbent firms.¹⁰⁶ The firms making those investments have done so as part of a “value-chain” strategy, in which the firms seek to commoditize a part of a value chain in which they are unlikely to dominate (like the operating system), hoping to extract value at some other part of a value chain (like the servers on which the operating system runs, the middleware that runs on the stack above the operating system, or the services necessary to assemble all of those pieces into a well-designed “solution”).¹⁰⁷

As the software has become commercialized, an increasing number of purely open-source firms have appeared.¹⁰⁸ For the most part, the largest of these firms depend on sales of services.¹⁰⁹ Because open-source software can be copied and sold freely by competitors, it is difficult to profit directly from product licensing.¹¹⁰ Accordingly, service companies dominate this market.¹¹¹ The recent battle between Oracle and Red Hat illustrates this point—Oracle apparently plans to copy Red Hat's version of Linux, presumably so that Oracle can profit from licensing products and providing

104. See Mann, *supra* note 20, at 9–10, 11 n.43 (noting that the quality and free dissemination of Linux, Apache, and Firefox have led to their increased use).

105. See *id.* at 24 (noting that these firms invest substantially in the development of Linux).

106. See *id.* at 12 (discussing the ties between open-source communities and incumbent firms).

107. *Id.* at 24–25.

108. See *id.* at 13–14 (discussing the proliferation of venture-backed open-source firms).

109. See *id.* at 34 (observing that the open-source model better suits services firms than products firms).

110. See *id.* at 22 (noting that the open-source model makes it impractical to prevent third parties from exploiting the results of research).

111. *Id.* at 34–35.

services related to Linux installations.¹¹² The relative disutility of patents for services firms together with the communitarian philosophy discussed above makes it unsurprising that there are few patents held by open-source firms.

Still, patents and other IP rights are crucial to the success of those strategies in several ways. Most obviously, the incumbent firms use IP to protect their positions in those parts of the value chain where they plan to compete. Thus, for example, although IBM has participated generously in the development of Linux and Apache, and has given the community ready access to the patents relevant to those projects, it has not abandoned the IP strategy that protects its investment in its server lines or software products like WebSphere.¹¹³ Also, to the extent that open-source communities are protected from patent litigation, it is because they operate under the umbrella of implicit promises of protection from the large patent-holding incumbents that support their communities.¹¹⁴

To be sure, major parts of the open-source community find these developments unsatisfying. The Free Software Foundation (FSF) led by Richard Stallman and Eben Moglen, for example, regularly decries the vice of patenting software.¹¹⁵ Its revisions of the GPL—the license under which Linux currently is distributed—reflect a continuing hostility to the increasing role that patents are playing in the industry.¹¹⁶ But on this point it is increasingly clear that the FSF no longer speaks for the community as a whole. Thus we see that Linus Torvalds has expressed great dissatisfaction with the FSF's position on these issues.¹¹⁷ This is because Torvalds is more concerned about wide deployment and use of Linux.¹¹⁸ Patent-related revisions to the GPL that make it less congenial to the large firms that participate in the Linux project are in tension with that concern.

C. *The Independent Inventor Channel*

The third channel is the independent inventor. This channel is the most controversial and least susceptible to generalization. Here, we make three points. First, this channel arguably plays a distinct role in providing valuable innovation in the industry. Second, independent inventors are likely to

112. For discussion of the Oracle strategy, see, for example, Stephen Shankland, *Oracle Has Yet to Prove Linux Cred*, CNET NEWS.COM, Oct. 27, 2006, http://news.com.com/Oracle+has+yet+to+prove+Linux+cred/2100-7344_3-6130071.html.

113. Mann, *supra* note 20, at 26.

114. *See id.* at 29 (noting that IBM, Sun, and Nokia have issued promises not to enforce their patents).

115. *See supra* note 8.

116. *See* Mann, *supra* note 20, at 20 (describing GPLv3, which prohibits an entity from using its own modification of open-source software if that entity attempts to patent that modification).

117. *See* Charles Babcock, *Torvalds on the Cost of GPL 3*, INFORMATIONWEEK, Mar. 19, 2007, at 40 (reporting Torvalds' position that the revisions of the GPL will reduce the simplicity of the previous version and unduly restrict what users can do with GPL software).

118. *See id.* (noting that Torvalds will not move the license commitment for the Linux kernel to GPLv3).

struggle more than other potential new entrants in transferring technology to incumbent firms. Third, building on the first two points, the market response is the creation of intermediaries to facilitate technology transfers between inventors and incumbents. Although the business models of the intermediaries are diverse, they generally describe themselves as patent acquisition or management firms and have been labeled pejoratively as “trolls.”¹¹⁹ Generally, those firms exhibit a variety of different strategies that respond to the various shortcomings that will hinder independent inventors attempting to exploit their software-related inventions.

1. *The Role of Independent Inventors.*—The first point is a relatively subjective one, though nonetheless significant. Although often vilified in the media as a novel and radical phenomenon, Part II documents the important challenge that independent inventors have presented to incumbents from the earliest days of the industry. Indeed, despite the rhetoric that characterizes the “troll” as an artifact of the rise of the Federal Circuit and related recent events,¹²⁰ the inventor that received what often is regarded as the first software patent, more than three decades ago, used his early patents to bolster efforts to create one of the first software products to enter into serious competition with the “free software” that IBM was then bundling with its mainframe computers.¹²¹

In the current milieu, industry sources (both in large firms and in patent acquisition firms) accept the notion that independent inventors in the software industry often have focused on larger “big picture” inventions while inventors at incumbent firms have largely focused on incremental improvements to existing product lines. Even at firms like Microsoft, with a corporate culture consciously directed toward forward-thinking innovation, the ever urgent need to protect and upgrade the firm’s core product lines makes it hard for researchers to do truly basic research about products that cannot be deployed in the near term.¹²²

119. E.g., Joe Beyers, *Perspective: Rise of the Patent Trolls*, CNET NEWS.COM, Oct. 12, 2005, http://news.com.com/rise+of+the+patent+trolls/2010-1071_3-5892996.html; see also John M. Golden, Commentary, “Patent Trolls” and Patent Remedies, 85 TEXAS L. REV. 2111, 2135 (2007) (“[U]nder current legal and economic conditions, nonpracticing or otherwise noncompeting patent holders [so-called trolls] might be at least as likely to be undercompensated as to be overcompensated.”). But see James F. McDonough III, Comment, *The Myth of the Patent Troll: An Alternative View of the Function of Patent Dealers in an Idea Economy*, 56 EMORY L.J. 189, 189–90 (2006) (demonstrating how “trolls” as market intermediaries provide liquidity, market clearing, and increased efficiency to patent markets—the same benefits that securities dealers provide to capital markets).

120. See, e.g., Mark D. Janis, *Reforming Patent Validity Litigation: The “Dubious Preponderance,”* 19 BERKELEY TECH. L.J. 923, 924 (2004) (connecting the success of “patent trolls” to the Federal Circuit’s presumption of patent validity).

121. Goetz, *supra* note 13, at 50–53.

122. Henry Chesbrough’s book *OPEN INNOVATION* (2006) provides detailed and perceptive documentation of the difficulties that incumbent high-tech firms have faced in their efforts to foster successfully innovative environments within the boundaries of their own companies.

Similarly, venture-backed start-ups necessarily have a short time horizon because the financing model contemplates success or failure in a *relatively* short time—typically less than a decade.¹²³ That financing model may be excellent for certain types of innovations, but the lesson of the discussion of venture-backed start-ups in the previous part is that the constraints of the venture capital model leave many valuable research opportunities unfunded.

At first glance, it might seem hard to put much weight on the distinction between independent invention and open-source development—apparently the essence of independence. And it surely is true that a grassroots strain of open-source development persists; the development evidenced by the thousands of small independent projects registered at SourceForge.¹²⁴ But historically the path to market traction (and funding) for open-source technology has been distinct from the independent inventor channel discussed in this section. As discussed above, the open-source projects that have gained substantial market traction ordinarily have succeeded through their adoption directly into the value chains of large incumbent firms.¹²⁵ It is also fair to say that the key to open-source success has been quality of execution coupled with easy interoperability. Linux and Apache were not visionary advances; they were high-quality solutions to pressing and immediate programming needs. In general, then, open-source development has not (so far at least) provided the path breaking advances at which independent inventors aim.

2. *Difficulties of Commercialization for Independent Inventors.*—Several overlapping structural considerations make it natural to expect that independent inventors might make valuable discoveries in the industry yet face substantial obstacles that complicate their efforts to commercialize their inventions. The first is the likelihood for many discoveries that direct exploitation by the inventor will be suboptimal, if not wholly impractical. The point is yet another variation on the problem mentioned above—the uncomfortable mapping of dozens (if not hundreds) of inventions into the thousands (or millions) of lines of code in a single software product. An independent inventor could not practicably commercialize an invention that improves Internet browsers, even if the invention is path breaking. Thus, the network effects that entrench existing products suggest that the optimal way to deploy a new invention related to Internet browsers is to sell it to one of the incumbent browser developers so that it can be incorporated into their product. As a matter of industry structure, that means that the independent software

123. See PAUL A. GOMPERS & JOSH LERNER, *THE MONEY OF INVENTION: HOW VENTURE CAPITAL CREATES NEW WEALTH* 99 (2001) (“Almost all venture funds are designed to be self-liquidating, that is, they must dissolve after ten to twelve years.”).

124. SourceForge hosts over 100,000 open-source projects uploaded by individual users. SourceForge.net, SourceForge.net: About SourceForge.net, <http://sourceforge.net/docs/about>.

125. See *supra* notes 105–07 and accompanying text.

inventor is more likely than the independent inventor in other fields to need the kinds of complex business, financial, and legal competencies that are necessary for successful negotiations with the large incumbent firms in the industry.

At the same time, those who populate the independent inventor channel are *less* likely to be well placed to conduct such negotiations successfully than innovators in the parallel channels.¹²⁶ For example, successful innovators in the venture-backed channel are likely to become incumbent firms themselves or to transfer their technology to incumbent firms in a consensual transaction.¹²⁷ The venture capitalists that control the destiny of venture-backed start-ups are a small group of players, often themselves former executives at incumbent firms, likely to enjoy professional and social relationships with the individuals at large firms that might be interested in the technology. Thus, it would be surprising if they could not agree upon a consensual arrangement for transfer of technology to an incumbent firm with a use for the technology. The rarity of patent infringement litigation between venture-backed start-ups and incumbent firms underscores the point: despite the oft-expressed concern about runaway patent litigation, we are aware of no lawsuit in the industry in which a venture-backed start-up has sued a substantial incumbent firm for patent infringement.

Similarly, products in the open-source channel seem to gain widespread commercial traction only after they have been adopted into the value chain of large incumbent firms.¹²⁸ Because the successful adoption typically involves a partial merging of the development community with employees of the incumbent (or incumbents) adopting the technology,¹²⁹ the frequency of adversarial dispute resolution is small. In any event, the limited frequency of patenting by open-source communities makes the offensive use of patents a strategy that is not readily available.

Lacking those relationships, independent inventors (here as in other contexts)¹³⁰ have been forced to resort to litigation to extract value from their

126. For this reason, the availability of injunctive relief, the issue contested in *eBay*, is crucially important to the intermediaries in this channel. See, e.g., Brief for Rembrandt IP Management, LLC as Amici Curiae in Support of Respondent at 11, *eBay Inc. v. MercExchange, L.L.C.*, 126 S. Ct. 1837 (2006) (No. 05-130) [hereinafter Brief of Rembrandt in *eBay*] (“In the absence of an injunction, a well-funded infringer either would not take a license from an independent inventor at all, or would do so on a playing field that vastly favored the infringer.”); Brief for United Inventors Ass’n & Technology Licensing Corp. as Amici Curiae Supporting Respondent at 8, *eBay*, 126 S. Ct. 1837 (No. 05-130) [hereinafter Brief of United Inventors Association et al. in *eBay*] (“Given the enormous imbalance of resources between big business and individuals, the predictable fight to an injunction is essential to make licensing a possibility.”).

127. See *supra* notes 100–01 and accompanying text.

128. See *supra* notes 105–07 and accompanying text.

129. See Mann, *supra* note 20, at 12 (noting that a large proportion of important Linux contributors are now employed by a large proprietary firm, the Open Source Development Labs, and its corporate sponsors).

130. See John R. Allison et al., *Valuable Patents*, 92 GEO. L.J. 435, 465 (2004) (finding that litigated patents issue disproportionately to individuals or small firms, but often are transferred

inventions.¹³¹ Thus, as we look at patent litigation in recent years in the software industry, we now see that a substantial share of litigation involves such firms or their subsidiaries.¹³² To the economist, it might seem odd that negotiations in this channel should fail so frequently. But software technology is not easy to transfer. For one thing, software inventors often will have difficulty in persuading potential purchasers of the value of their inventions without disclosing the inventions in some detail. Given the difficulty of protecting the value of the technology even with a well-considered patenting program, independent inventors reasonably might be reluctant to make such disclosures. But a failure to disclose (by hypothesis) will make it harder to persuade a purchaser to pay the “true” value of the technology—a standard instance of Arrow’s information paradox.¹³³ In the end, where venture-backed firms could use their connections to get a receptive hearing from incumbent firms, independent inventors that claim to have developed valuable technology are more likely to be dismissed as “kooks.”¹³⁴ If they cannot obtain a serious hearing from large firms, their only recourse is to resort to legal coercion.¹³⁵

between issuance and litigation); Jean O. Lanjouw & Mark Schankerman, *Stylized Facts of Patent Litigation: Value, Scope and Ownership* 26 (Nat’l Bureau of Econ. Research, Working Paper No. 6297, 1997), available at <http://papers.nber.org/papers/w6297.pdf> (“[I]ndividual-owned patents are at least as likely to be litigated as are corporate-owned patents.”).

131. Jack Goldsmith and Tim Wu’s discussion of the troubled development of an online music market provides an instructive parallel. See JACK GOLDSMITH & TIM WU, WHO CONTROLS THE INTERNET? 105–28 (2006). It should have been clear to all concerned parties by 2000 that the efficiencies of online music distribution eventually would compel some method of easy digital distribution of music online. But the brash early technology start-ups like MP3.com and Napster had no success at all in reaching consensual arrangements with the large media providers. See WILLIAM W. FISHER, PROMISES TO KEEP: TECHNOLOGY, LAW AND THE FUTURE OF ENTERTAINMENT 98–102, 110–20 (2004) (detailing the early history of MP3.com and Napster, and the subsequent lawsuits by media providers). But Steve Jobs, largely because of personal relations that spanned the divide between technology firms and the large media companies, was able to reach agreements in one fell swoop with all of those companies, facilitating both the iTunes store and the iPod. See GOLDSMITH & WU, *supra*, at 118–21 (discussing the success of iTunes).

132. That is not to say that there is never litigation among incumbents—IBM’s recent filings against Amazon.com, see *infra* note 151, and the high-profile litigation between AT&T and Microsoft, see *Microsoft Corp. v. AT&T Corp.*, 127 S. Ct. 1746 (2007), underscore the occasional inability of large firms to reach rational settlements of these kinds of disputes.

133. See Mann, *supra* note 103, at 2267–68 (discussing Arrow’s information paradox).

134. For example, despite the general perception in the media (and on Capitol Hill) that NTP’s patent claims related to the BlackBerry were unfounded, see Ian Austen & Lisa Guernsey, *A Payday for Patents ‘R’ Us*, N.Y. TIMES, May 2, 2005, at C1 (discussing the view of critics that NTP is a “patent troll”), some industry sources portray Tom Campana (the inventor of the patent in question) as a thinker of great perception and foresight, see, e.g., Richard Shim, *Key Figure in BlackBerry Case Dies*, CNET NEWS.COM, June 17, 2004, http://news.com.com/Key+figure+in+BlackBerry+case+dies/2100-1041_3-5238198.html (describing Campana as a “tireless and inventive engineer committed to perfecting the best that wireless technology has to offer”).

135. One interesting, developing battleground in this area is the question of “transparency.” Incumbent firms call for transparency in the ownership of patenting, so that they readily can identify the real parties in interest when patents are issued or transferred. Intermediaries anticipating litigation, however, prefer that their acquisition of patents go unnoticed. This could be true for a spectrum of reasons of varying legitimacy, ranging from a Lemelson-like desire to allow

3. *Patent Enforcement Intermediaries.*—In a world of perfect markets, the conditions described above would summon into existence intermediaries specializing in the particular competencies that independent inventors are likely to lack: the ability to enforce patents aggressively against incumbent firms, the ability to raise funds to support the continuing development and exploitation of the technology, and (most important from a social perspective) the ability to facilitate the deployment of the technology by licensing it to the firms best placed to use it. There can be no doubt that a substantial group of these firms has arisen—some of the most prominent (in alphabetical order) include Acacia Technologies Group, Altitude Capital, Intellectual Ventures, and Rembrandt IP Management.¹³⁶ Indeed, if there is anything odd about the situation, it is not that some firms have arisen to fulfill those functions but that they have taken so long to appear. Because none of the considerations discussed above explaining the rise of these intermediaries has changed substantially in the last decade, it is not easy to see why they have arisen so rapidly in the last few years alone.¹³⁷

The activities of those firms illustrate, however, that each of them is pursuing a distinct strategy. The best way to understand those strategies is to recognize that different inventors will fail in commercialization for different reasons. Thus, the optimal exploitation strategies for different technologies will be different, which makes it natural to expect that a range of intermediaries would arise specializing in different strategies. As illustrated in Figure 8, we organize those strategies along two different dimensions: the type of opportunity that the intermediary acquires and the source of funds on which the intermediary relies.

a. Acquiring Litigation or Technology?—The most fundamental distinction relates to the type of asset on which the intermediary focuses. Here, we discern a spectrum from pure litigation on one end (with relatively

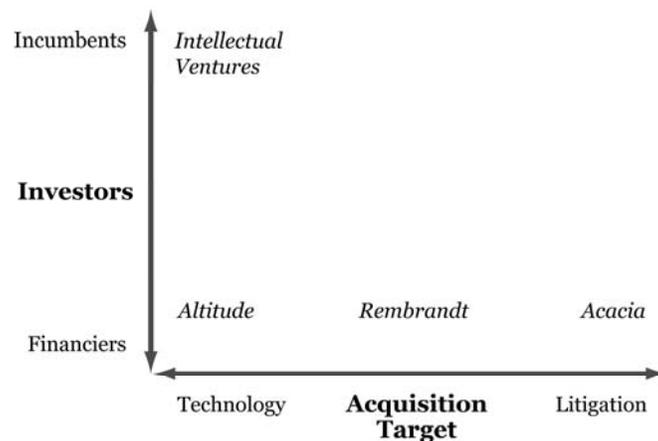
competitors to become more dependent on a patent *before* revealing its existence to more pedestrian concerns, such as a desire to control the forum in which litigation will occur. It is not entirely clear what the best solution is, but it is worth noting that many large companies have their patents held by a separate, nonpracticing company that has no assets other than intellectual property. See Brad Stone, *Factory of the Future?*, NEWSWEEK, Nov. 22, 2004, at 60 (noting that Microsoft, Intel, Sony, Nokia, and Apple have some of their patents held by a nonpracticing company called Intellectual Ventures).

136. There are many smaller firms that exploit particular technologies. E-Pass Technologies, for example, exists primarily to support the licensing of its patented smart-card product. See E-Pass Technologies, Inc., Corporate Information, <http://www.e-pass.com/corporateinfo.htm> (“The company is primarily organized to promote the sales and marketing of the e-pass smart card . . .”).

137. The disparaging and poorly reasoned discussion in the concurring opinion of Justice Kennedy in *eBay Inc. v. MercExchange, L.L.C.*, 126 S. Ct. 1837, 1842–43 (2006) (Kennedy, J., concurring), certainly has contributed to the high visibility of the issue as a policy matter and the simplistic pejorative use of the term “troll” to refer to the wide variety of entities discussed here. Justice Kennedy made a passing reference to what he saw as the suspect quality of business-method patents, supported only by a reference to an article making several arguments that business-method patents were *unconstitutional*, arguments that were strange to say the least. *Id.*

little regard for technology) to pure technology at the other end (with little regard for litigation). Thus, at one end of the spectrum we would place firms like Acacia, which function much like the paradigmatic securities class action law firm. Essentially, those firms search for opportunities to acquire patents, frequently from defunct firms.¹³⁸ With the patents in hand, they search broadly for companies that might be regarded as infringing those patents, often in market sectors far removed from the market at which the patent originally was directed. Whenever they can present a colorable claim, they should be able to obtain a settlement from the defendant that at least reflects the expected present value of the defendant's litigation costs (what some might deprecatingly call a "nuisance" settlement). That activity will be privately profitable whenever those settlements exceed the often trivial cost that the intermediary must pay to acquire the patents. The net social contribution of that activity would depend on the balance between the funds that are flowing back to the original inventor (and thus providing an incentive for the innovative activity that generated the patent), balanced against the resources consumed in the litigation to enforce the patent.

Figure 9: Schema of Patent Exploitation Intermediaries



At the other end of the spectrum are firms focused more on the acquisition of technology than on litigation. Here we place a firm like Altitude Capital, a firm with a relatively large share of veterans of hedge

138. Acacia in particular has brought suits in several cases already relying on patents purchased from insolvent entities. See Jeff Sandford, *Stream Media Faces Lawsuit Test*, WEB HOSTING MONTHLY, Sept. 2003, at 13, 13–14 (discussing Acacia's acquisition of five patents for streaming media technologies and the company's expectation of a large payoff from suits to defend those patents). Because many of those entities are failed venture-backed start-ups, the activity affords a link through which assets in failed venture capital start-ups can be brought into the independent inventor channel. However, it is not clear that the availability of that channel is important to investment decisions.

funds and of investment banks.¹³⁹ In general, the goal is to earn a profit by skillful balancing of present and future cash flows related to the technology. Thus, a typical transaction for Altitude would involve immediate payment to the inventor in return for the present acquisition of a patent. Altitude would hope to recoup the payment over time by revenues obtained from licensing the patent to an incumbent with a use for the technology. For that transaction to succeed, Altitude must accurately assess the value of the technology—the likely future revenues that the patent will generate—and also must convert those revenues to an anticipatory payment stream accruing to the inventor. If it is skilled at both of those tasks, Altitude should be able to earn a good return on the funds that it invests. The social value of the activity, again, would turn on the balance between the funds flowing back to the original inventor and the transaction costs associated with Altitude's activity. If Altitude can succeed in generating sufficient revenue streams to earn a profit while both avoiding litigation and returning a substantial stream of funds to the original inventors, it is hard to quarrel with the model from a social perspective.

Somewhere in between are firms (like Rembrandt) that buy into existing disputes and invest substantial resources to develop the dispute.¹⁴⁰ The emphasis is on patent disputes that are already mature, in the sense that the technology already has been deployed in the market, so that the patents write onto existing products. The core competency at which such a firm aims is an ability to precisely estimate the likelihood that the patent will be held valid, the likelihood that the defendant's products will be found to infringe the patent, and the likely amount of damages a court will award for the infringement. Those firms closely resemble the litigation-financing firms that have proliferated throughout the legal community in recent years,¹⁴¹ with the addition of a particular expertise in patent litigation.

b. Funded by Financiers or Incumbents?—The discussion above also suggests that the identity of the investor in the intermediary should have structural significance. Most of the patent-exploitation intermediaries rely on funds from external investors—pure financiers—with no particular role in the industry, and no strategic goal other than a substantial return on their investment.¹⁴² Indeed, some intermediaries explain that the detached view of the financier is central to the success of their model because it allows them to

139. See Altitude Capital Partners, <http://www.altitudecp.com/team.html> (providing the biographies of Altitude Capital employees).

140. See Brief of Rembrandt in *eBay*, *supra* note 126, at 1–2 (describing Rembrandt's activities).

141. E.g., Alison Frankel, *Helping Underfunded Plaintiffs Lawyers—at a Price*, LAW.COM, Feb. 13, 2006, <http://www.law.com/jsp/article.jsp?id=1139565913200>.

142. See Nathan Vardi, *Patent Pirates*, FORBES, May 7, 2007, at 44 (describing a private investment firm's investment in an exploitation intermediary solely for the purpose of receiving a percentage of the winnings in a pending patent lawsuit).

pursue patent enforcement and litigation in a clinical and perfectly rational manner, unencumbered by the distractions of social or business relations that would come with funds from an incumbent.¹⁴³ This unclouded and calculating rationality that independence brings seems to be an important cultural attribute of these firms—it came up in one way or another in all of our conversations with representatives of these firms.

But not all firms have that perspective. In particular, Nathan Myhrvold's Intellectual Ventures entities rely on funding from a large set of the most important incumbents in the industry, with the conspicuous exception of IBM.¹⁴⁴ Returning to the discussion above, it is easy to see what Intellectual Ventures provides that the financier-funded intermediaries cannot—the ability to use relational ties to overcome the information paradox that makes it so difficult for independent inventors to obtain fair value for their technology from large incumbent firms. Thus, it should be no surprise to see that Intellectual Ventures appears to have been much more successful than any of the other prominent intermediaries at negotiating license agreements with major incumbent firms.¹⁴⁵

Looking at the “supply” side of the equation as well, it is easy to understand why incumbents would so willingly invest in an intermediary controlled by a person whom they know (like Myhrvold). If the incumbent firms believe that they are wasting resources on litigation against “trolls” because of legal rules that (in the view of incumbents) give trolls an unfair return on their patents, the natural response of a rational incumbent would be to invest in the “troll” directly, so that the incumbent could recover the “unfair” returns that the troll earns in litigation against the incumbent. Whether incumbents are correct in that assessment of the situation, it seems fairly clear that it is the view of many of the incumbents, and something akin to such a view has helped to drive the investments in Myhrvold's enterprises.

In any event, the investments should be privately profitable if Myhrvold can obtain license revenues from the incumbent firms that are adequate in light of the funds he spends to acquire patents. From a social perspective, assessing the value of the activity is similar to the assessment of the firms discussed above. The question is whether the incentives arising from the funds that flow to original inventors through Myhrvold's patent acquisitions exceed the drag on innovation reflected by the licensing fees that the incumbent firms pay. Given the relatively low transaction costs of the licensing, it

143. See Alan Cane, *Trolls Control the Ricketty-Rackety Bridge of Intellectual Property*, FIN. TIMES (London), Sept. 20, 2006, at 2 (noting that exploitation intermediaries are free to seek injunctions because they have no market share or business relations to lose).

144. Stone, *supra* note 135, at 60.

145. This discussion substantially oversimplifies the business model of Intellectual Ventures. A large part of the acquisition strategy of Intellectual Ventures is wholly unrelated to any reasonably foreseeable enforcement of the patents. Rather, it is designed to provide freedom to innovate in areas in which Intellectual Ventures hopes to be filing its own patent applications based on its own innovative activities. See *id.* (describing Intellectual Ventures' business plan).

is difficult to quarrel with the model from a social perspective (at least in the absence of some problem with the quality of the patents that Myhrvold acquires and enforces).

V. Conclusion

The puzzle that primarily motivates this Article is why the pharmaceutical and manufacturing industries have monolithic perspectives on patent policy while each firm in the software industry seems to have a different position on patent policy—a position that is likely to change from time to time. The usual answer is that the low ability of patents to appropriate innovation in the industry makes the patents less useful and thus lowers the social value of granting them.¹⁴⁶ But that explanation would support a pattern of persistent ambivalence. What we see on the contrary is heated disagreement and instability of perspective.

We think the history and data presented here provide a useful lens for understanding the views on patent policy of those in the industry. For one thing, the role of patents has changed dramatically from the mid-1960s to the present. In the mid-1960s, patents only had value for firms hoping to challenge IBM's dominance in the production of computers and software.¹⁴⁷ By the twenty-first century, in contrast, the industry has matured into a complex pattern, with at least four distinct groups (incumbents, venture-backed firms, open-source communities, and independent inventors and associated intermediaries), each with a different relation to the patent system.

For many years, there was a debate over the fundamental question of patentability, a debate that remains open in the European Union to this day.¹⁴⁸ In recent years, however, policy debates have shifted away from that question to converge on the idea that the system is broken in ways that call for changes in various details of patent policy.¹⁴⁹ Thus, the main area in which there is a realistic likelihood of attempted retrenchment on patentability in this country is in the area of business methods. Because of the common confusion of technical software patents with software-implemented business-method patents, this presents a potential problem for software firms. The natural response by software firms may be to publicly differentiate the two and distance themselves from the latter. IBM argued in *Metabolite*,¹⁵⁰ for example, in favor of ratcheting up the “useful application” standard to

146. See Mann, *supra* note 62, at 978 (noting that a basic problem for software firms at all stages is the sense that even with a patent it is often difficult for a firm to appropriate the value of its invention).

147. See *id.* at 1005 (describing IBM's historic market dominance).

148. See *supra* notes 5–8 and accompanying text.

149. See NAT'L RESEARCH COUNCIL OF THE NAT'L ACADS., A PATENT SYSTEM FOR THE 21ST CENTURY 87–94 (Stephen A. Merrill, Richard C. Levin & Mark B. Myers eds., 2004) (arguing that the obviousness test should be changed).

150. *Lab. Corp. of Am. Holdings v. Metabolite Labs., Inc.*, 126 S. Ct. 2921 (2006) (*per curiam*).

require some “technological contribution,” which would bar the issuance of business-method patents that are not implemented in software or some other tangible product.¹⁵¹

Another important area likely to see reform is the topic of patent quality. Much of the criticism of patents focuses on a small number of highly visible and dubious patents. Academics for several years now have been raising concerns about the quality of PTO patent review.¹⁵² Those concerns focus on the difficulties that the PTO has faced in identifying the relevant prior art, especially in new technologies like software.¹⁵³ The obvious policy response, if the details can be worked out, is some form of “community patent review” in which firms in the area of a proposed patent would have an opportunity to suggest relevant prior art before a patent is issued.¹⁵⁴ Similarly, on the PTO’s side, the persistent public complaints about notoriously bad patents have resulted in a pointed emphasis on patent

151. Brief of International Business Machines Corp. as Amicus Curiae in Support of Neither Party at 30, *Metabolite*, 126 S. Ct. 2921 (2006) (No. 04-607); see also Supplemental Letter Brief of United States Patent and Trademark Office, *In re Comiskey*, No. 2006-1286 (Fed. Cir. filed Jan. 30, 2006) (arguing that business methods are not patentable under 35 U.S.C. § 101 (2000)). The patents at issue in *IBM v. Amazon.com, Inc.*, No. 9:06 Civ. 242 (E.D. Tex. filed Oct. 23, 2006), and *IBM v. Amazon.com, Inc.*, No. 6:06 Civ. 452 (E.D. Tex. filed Oct. 23, 2006) appear to be precisely the kind of “technical method” patents that would be upheld under the position IBM urged in *Metabolite*. See FedCirc.us, Case Page for *IBM v. Amazon*, <http://www.fedcirc.us/case-pages/ibm-v.-amazon.html>. To be sure, some believe that “business methods” defines such an imprecise category that any effort to limit their patentability will be undermined by arbitrary line drawing and strategic gamesmanship by applicants. See John R. Allison & Starling D. Hunter, *On the Feasibility of Improving Patent Quality One Technology at a Time: The Case of Business Methods*, 21 BERKELEY TECH. L.J. 729, 758–89 (2006) (discussing the insurmountable difficulties encountered in defining a “business method”); Jeffrey R. Kuester & Lawrence E. Thompson, *Risks Associated with Restricting Business Method and E-Commerce Patents*, 17 GA. ST. U. L. REV. 657, 675–79 (2001) (discussing proposed legislation that would have raised the bar for obtaining business-method patents).

152. See, e.g., John R. Allison & Mark A. Lemley, *Empirical Evidence on the Validity of Litigated Patents*, 26 AIPLA Q.J. 185, 206 (1998) (“[W]e cannot predict with confidence that patents in general are more likely to be held valid than invalid.”); Bhaven N. Sampat, *Determinants of Patent Quality: An Empirical Analysis 3* (Sept. 2005) (unpublished manuscript), available at http://siepr.stanford.edu/programs/SST_Seminars/patentquality_new.pdf_1.pdf (finding that patent examiners are less likely to discover nonpatent prior art and foreign patents).

153. Empirical evidence reveals, however, that problems with patent quality are not localized—at least not in the case of software or software-implemented business methods. See, e.g., John R. Allison & Emerson H. Tiller, *The Business Method Patent Myth*, 13 BERKELEY TECH. L.J. 987, 1036–77 (finding that Internet-related business-method patents issued through December 31, 1999, were not of lower quality and value than the average patent and patents in most other technology areas); Allison & Mann, *supra* note 7 (manuscript at 20–41) (finding evidence in a data set of 20,000 computer-industry patents that software patents vary greatly in quality and value, but as a whole appear to be of higher quality and value than nonsoftware patents issued to the same group of firms and of higher quality and value than the general population of patents); Allison & Hunter, *supra* note 151, at 789 (arguing that problems with patent quality are systemic rather than localized and that reform efforts should focus on all subject matter areas); Allison et al., *supra* note 130, at 448–64 (finding that patents in all areas of technology in the general population of patents are of apparently lower quality and value than those in all areas of technology that are *litigated*).

154. For details on the progress of that initiative, see The Peer to Patent Project: Community Patent Review, <http://dotank.nyls.edu/communitypatent/>.

quality in the PTO's proposed strategic plan for 2007–2012.¹⁵⁵ The central concern is that without serious review of patent applications it makes little sense to continue to give patents the presumption of validity that traditionally goes with issuance.

Even if those criticisms are anecdotal, most of the large patenting firms agree that the PTO could do a better job of locating relevant prior art and processing applications expeditiously.¹⁵⁶ Thus, although those firms rely heavily on patents, it makes sense for them to support changes that would “raise the bar” of patentability. The support for “gold-plated patents” suggests that those firms, for the most part, believe they would do just as well under a system in which it was harder to obtain patents than it is now.¹⁵⁷ Similarly, the positions taken in the *KSR* case suggest a general consensus, at least among large firms, that the standard for obviousness should be changed to make it easier for the PTO to reject patents.¹⁵⁸

Because these kinds of reforms affect only firms that apply for patents (or who compete in sectors with those who do), debate over them has been relatively technical. That is not to say that the reforms affect all firms equally. For example, proposals for community patent review promise more benefits to large firms with substantial patenting infrastructures than they do to smaller venture-backed start-ups. It is to say, however, that the various initiatives have gotten more attention from the large incumbents than from smaller firms.

The most prominent topic for debate has been the need for litigation reform. Limitations on the availability of injunctive relief have appeared in recent patent reform bills and were urged upon the Supreme Court in *eBay Inc. v. MercExchange, L.L.C.* Compared to patent-quality issues, rules on patent enforceability will affect different strategies in markedly different ways. So, for example, in *eBay* representatives of the independent-inventor community and other technology licensors like Qualcomm predictably pressed for all but automatic injunctive relief.¹⁵⁹ By contrast, representatives

155. U.S. PATENT AND TRADEMARK OFFICE, 2007–2012 STRATEGIC PLAN (2007), available at <http://www.uspto.gov/web/offices/com/strat2007/stratplan2007-2012.pdf>.

156. See, e.g., John P. Mello Jr., *Patent Office Says Critics Wrong, Complete Review Provided*, TECHNEWSWORLD, Apr. 12, 2005, <http://www.technewsworld.com/story/42207.html> (reporting criticism by IBM's vice president for intellectual property that the PTO is unable to expeditiously process applications or adequately review prior art).

157. The idea of gold-plated patents is that applicants who are willing to pay for a more thorough prior art search and more rigorous examination should receive a stronger presumption of validity for their patents than those who are not. Mark Lemley et al., *What to Do About Bad Patents?*, REGULATION, Winter 2005–2006, at 10.

158. See, e.g., Brief of IBM in *KSR*, *supra* note 4, at 26–30 (proposing an alternative test for nonobviousness that would allow the PTO to reject more patents).

159. See Brief Amici Curiae of Martin Cooper et al. in Support of Respondent at 2, *eBay Inc. v. MercExchange, L.L.C.*, 126 S. Ct. 1837 (2006) (No. 05-130) (“[T]he right of exclusivity means nothing without injunctive relief.”); Brief for Technology Patents & Licensing Inc. et al. as Amici Curiae Supporting Respondent at 30, *eBay*, 126 S. Ct. 1837 (No. 05-130) (urging the Court not to disturb “the general rule that, in the usual case, injunctive relief is appropriate where infringement

of the open-source community and firms that are more likely to be defendants in patent litigation lined up to argue vigorously for limitations on injunctive relief.¹⁶⁰ Indeed, many of them argued for a categorical bar on injunctive relief in favor of “nonpracticing entities,”¹⁶¹ a position received sympathetically by some Justices.¹⁶²

Many industries consolidate as they mature into a small group of relatively homogeneous firms. If that ever happens in the software industry, it will not happen soon. Business models in the software industry differ starkly from firm to firm. The still increasing variety in the uses to which software is put offers one reason. Another comes from the common tactic of technology companies to leverage competencies at one part of the value chain against commoditization at another—IBM supporting “free” software that is compatible with its proprietary hardware, software, and service offerings; Adobe supporting one free product that facilitates use of its higher end proprietary products; even Microsoft supporting free small business accounting software that should increase demand for its proprietary product line.¹⁶³ The variety of strategies, coupled with the relative difficulty of using IP to appropriate innovation in software, underscores the importance of attention to context in designing IP rules for the industry. The fact that every sector is offering views that support its own interests does not mean that

and validity of a patent have been proved”); Brief of Amici Curiae Qualcomm Incorporated and Tessera, Inc. in Support of Respondent at 4, *eBay*, 126 S. Ct. 1837 (No. 05-130) (“The current patent injunction principles do not require any judicial adjustment.”); Brief of Amicus Curiae Pharmaceutical Research and Manufacturers of America in Support of Respondent at 3, *eBay*, 126 S. Ct. 1837 (No. 05-130) (“Given the ease with which infringers can reverse engineer pharmaceutical products . . . injunctive relief offers in many circumstances the only effective protection.”); Brief of Rembrandt in *eBay*, *supra* note 126, at 1–3 (arguing that injunctive relief should remain available to “non-practicing entities” that invest in patents but do not practice them); Brief of Wisconsin Alumni Research Foundation et al. as Amici Curiae in Support of Respondent at 8, *eBay*, 126 S. Ct. 1837 (No. 05-130) (arguing that the Court should not change the rule that “a patentee’s non-use of an invention does not bar the issuance of a permanent injunction”); Brief of United Inventors Association et al. in *eBay*, *supra* note 126, at 3 (“[T]his Court should reaffirm its precedents rejecting compulsory licensing and excluding non-use as a factor in granting patent injunctions.”).

160. See Brief of Business Software Alliance in *eBay*, *supra* note 4, at 3 (arguing that district courts should apply traditional equitable factors in patent cases to determine whether injunctive relief is appropriate in a particular case); Brief of Research in Motion, Ltd. as Amicus Curiae in Support of Petitioners at 3, *eBay*, 126 S. Ct. 1837 (No. 05-130) [hereinafter Brief of Research in Motion in *eBay*] (“[I]njunctive relief . . . is a discretionary remedy that may be accorded to patent owners only upon consideration of the equities of a particular case.”).

161. See Brief of Business Software Alliance in *eBay*, *supra* note 4, at 23 (arguing that it would be difficult for a nonpracticing entity to demonstrate the irreparable harm necessary for injunctive relief); Brief of Research in Motion in *eBay*, *supra* note 160, at 14 (arguing that a patent assertion firm that “values its claim based solely on the damage it can inflict does not show irreparable harm”).

162. See *eBay*, 126 S. Ct. at 1842 (Kennedy, J., concurring).

163. See, e.g., Candace Lombardi, *Microsoft Tries to Lure ‘Mom and Pop’ Companies*, CNET NEWS.COM, Oct. 30, 2006, http://news.com.com/2100-1012_3-6130582.html (describing Microsoft’s Office Accounting Express 2007 as “an example of how Microsoft has been forced to change its business model as more software for small-business owners becomes freely available”).

policymakers should ignore those views; it means that they should be sure that any reforms they adopt do not accidentally elevate the temporary interests of firms using one strategy over those of firms using another.